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JULY 1928

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OF THE

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Vol. XLVII JULY 1928 Number 7

TABLE OF CONTENTS

Papers, Discussions, Reports, Etc.

Institute and Related Activities

Continued on next page

A REQUEST FOR CHANGE OF ADDRESS must be received at Institute headquarters at least ten days before the date of issue with which it is to take effect. Duplicate copies cannot be sent without charge to replace those issues undelivered through failure to send such advance notice. With your new address be sure to mention the old one, indicating also any changes in business connections.

(The Journal of the A. I. E. E. is indexed in Industrial Arts Index.)

Current Electrical Articles Published by Other Societies

Electrical Communication, April 1928

Pioneers of Electrical Communication, by R. Appleyard

Institute of Radio Engineers, Proceedings, June 1928

Beam Transmission of Ultra Short Waves, by Hidetsugu Yagi

The Piezo-Electric Resonator and Its Equivalent Network, by K. S. Van Dyke

Some Correlations in Radio Reception with Atmospheric Temperature and Pressure, by Greenleaf W. Pickard

Technical Consideration Involved in the Allocation of Short Waves, by Lloyd Espenschied

The Navy's Primary Frequency Standard, by R. H. Worrall and R. B. Raymond

A Transmitter Modulating Device for the Study of the Kennelly-Heaviside Layer by the Echo Method, by M. A. Tuve and O. Dahl

A Compensated Electron-Tube Voltmeter, by H. M. Turner

Four-Element Tube Characteristics as Affecting Efficiency, by D. C. Prince

Detection with the Four-Element Tube, by J. R. Nelson

The Screen-Grid Tube, by N. H. Williams

Iron & Steel Engineer, April 1928

Effect of Grounding on the Reliability of Relay Operation, by E. A. Hester, and B. M. Jones

Effects of Grounding on Telephone Interference, by J. J. Pilliod

Effect of Grounded Neutral on the Efficiency of Lightning Protection Equipment, by K. B. McEachron

Experiences in the Steel Industry with the Grounded Neutral, by A. C. Cummins

Experience of the Public Utility with Grounded Neutral, by G. S. Humphrey

Theory of Grounding, by F. C. Hanker

N. Y. Railroad Club Proc., February 1928

Atlantic Ocean Conquered—Marvelous Achievement of Oceanic Telephony, by H. J. Carroll

JOURNAL OF THE A. I. E. E.

DEVOTED TO THE ADVANCEMENT OF THE THEORY AND PRACTISE OF ELECTRICAL ENGINEERING AND THE ALLIED ARTS AND SCIENCES

Vol. XLVII JULY, 1928 Number 7

Storage Battery Locomotives for Mine Safety

The advantage of the storage-battery locomotive with respect to safe haulage in gassy coal mines is emphasized in a paper by L. C. Ilsley issued by the United States Bureau of Mines. In coal mining, the application of the storage-battery locomotive is chiefly in gathering service in competition with animal or cable-reel locomotives. The locomotive delivers empty cars to the rooms or working places where the coal is being mined and hauls the loaded cars from the rooms. The length of haul depends upon the distance of the junction point from the active workings of the mine. As a rule, the haulage from the junction point to the foot of the shaft or bottom of the slope is done by trolley locomotives, but in some instances, where the grades permit, the main-line haulage work is performed by storage-battery locomotives.

Those who originally designed storage-battery locomotives had no thought of safety in mind, as these early types of storage-battery locomotives, with open controller, open motor, open rheostats, flimsy headlights, and crude wiring, were very dangerous electrically and not at all suitable for use in a gassy mine, says Mr. Ilsley. These locomotives, however, were placed in mines in which open lights were permitted and they replaced considerable animal haulage. Later, they were gradually introduced in mines where closed lights were used, but in most cases these mines were not extremely gassy.

Safety engineers gradually began to consider the possibilities of so changing the design of storage-battery locomotives, which were becoming a standardized product, that they might be used with reasonable safety in gassy mines. Representatives of locomotive manufacturers and engineers of the Bureau of Mines cooperated in preparing tentative standards for such equipment, and in November, 1919, a formal standard was issued. Permissible storage-battery locomotives have since been developed by nearly every electrical locomotive manufacturer and are now readily available to mine operators. The permissible storage-battery locomotive offers a high degree of safety, and has certain inherent safety advantages not common to any other type of equipment.

The simplicity and safety of this kind of equipment have improved continuously. Battery-box covers, which were weak, have been materially strengthened and mechanical means adopted for handling these heavier covers. The wiring between accessories has been simplified and better schemes adopted for its mechanical protection. Improved design of battery jars and battery plates has resulted in much longer battery life and in more reliable service. A better understanding of battery installation has resulted in less breakage of jars.

From the first, the Bureau of Mines has looked upon the permissible type storage-battery locomotive with favor because of its inherent safety advantages. That its energy is self-contained and limited to the immediate zone of the locomotive is a safety factor of great importance. In the trolley type of equipment one necessarily uses the track return, and the danger zone from the return current may extend throughout the mine. Poor bonding or no bonding may force the return current back toward the face. A storage-battery locomotive does not use, or need, the overhead trolley with its constant shock menace and fire hazard, and with the possibility of trolley or feeder circuits becoming a factor in ignition of gas or coal dust. The trolley is an alleged cause of some very serious disasters. A storage-battery locomotive does not depend upon a trailing cable,—a fact again very much in its favor. Although trailing cables have been allowed on permissible equipment, they are a constant source of worry and are the weakest link in the Bureau's approval system. Locomotives that depend upon a trailing cable use a trolley pole after they leave the immediate zone covered by the short length of cable. The permissible type storage-battery locomotive can operate in any part of a mine with the same factor of safety, and at night, or any time when not in operation, it can be brought to a point of absolute safety, whereas, with a wired system, the wire must be left behind and exposed to all the hazards of roof and timber falls.

Frequency Standardization

In a paper which appeared in the May, 1928 *Proceedings of the Institute of Radio Engineers*, p. 579, under this title, J. H. Dellinger, chief of the radio section of the Bureau of Standards, shows that frequency standardization of hitherto laboratory character only has become of first-rank importance in reducing radio interference. The recent International Radio Conference recognized frequency as the cornerstone in the

radio structure by devoting its major attention to a frequency allocation to provide for the orderly development of all radio services.

Because of increasing use of all available radio channels, particularly those for broadcasting and very high frequencies, the requirements of frequency measurements are a hundred times more rigorous than they were five years ago. The perfection of standards and measurements to the necessary accuracy requires the most intensive work by the Government and by various large organizations to produce standards and instruments that can be used to keep each radio station operating on its own channel. This development has been facilitated by a special cooperative plan organized by the Bureau of Standards a year ago and involving the Commerce, Navy, and War Departments, the General Electric Co., the Westinghouse Co., American Telephone & Telegraph Co., Radio Corporation of America, and the General Radio Co.

Piezo oscillators are now available to hold radio station frequencies extremely constant. For instruments of this type equipped with temperature control, national and international comparisons have shown that they are reliable to a few parts in 100,000.

This brings in sight the possibility of the use of special piezo oscillators in broadcasting stations, which will hold the frequency so close that several such stations can operate simultaneously without heterodyne interference on the same frequency. This is the only practical scheme developed so far for solving the problem of too many broadcasting stations.

The use of frequency standards of this high accuracy is also vital to all users of very high frequencies. Many more high-frequency channels will become available when all stations use with great accuracy the best available frequency standards and keep the stations on their frequencies.—*Technical News Bulletin.*

Some Leaders of the A. I. E. E.

Frank G. Baum, Vice-President of the Institute 1906-1908, pioneer in hydroelectric and transmission developments of the Pacific Coast, inventor, and now consulting hydroelectric engineer, was born at Ste. Genevieve, Missouri. He was graduated from Stanford University in 1898 with the degree of A. B. and the following year obtained his degree in Electrical Engineering from that same school.

To bring the consumer and producer together is a most interesting economic problem of any age, and this was the work which Mr. Baum made the keynote of his remarkable career, in which he has achieved more than national distinction. With unusual insight, he recognized the fact that the greatest loss in efficiency rested with the intermediary between the consumer and the producer; he saw that if it were possible to produce, distribute, and consume all other products as efficiently and as simply as electricity, this loss would be reduced 90 per cent, and upon this basis, he decided for himself that electrical methods would always be the ideal. To use his own words, he believed that "sometime in the future, a nation's civilization will be measured in terms of kilowatt-hours consumed per human being per year, because as the kilowatt-hours consumed are large, so the non-productive inefficient labor will be small. Therefore a nation having large natural water-power need never fear decay." This scientific vizualizing of what the harnessing of water-power will do incited Mr. Baum's earliest work. After his graduation from Stanford University, where with true American spirit he made his own way, he entered the employ of the Standard Electric Company of California, where he determined line-charging currents and their reaction for three-phase transmission. On the basis of this and other work the frequency of 60 cycles and the grounded system—now recognized as standard—were adopted. From 1900 to 1902 he was instructor in electrical engineering at Stanford University, at the same time doing special work in the transmission of electrical energy for the Bay Counties Power Company and others. In March 1902 he became electrical engineer of the California Gas & Electric Corporation. Since 1907 Mr. Baum has practised consulting engineering with special reference to hydroelectric power developments.

The conception and much of the engineering outline of the Pit River power development of the Pacific Gas & Electric Company are due to Mr. Baum's foresight and appreciation of hydroelectric possibilities. It was he who designed Hat Creek No. 1, Hat Creek No. 2 and Pit River No. 1, the 220,000-volt Pit transmission line and the great Vaca substation at the receiving end. His work during the past two years in developing insulators and regulation systems is outlined in his paper *Voltage Regulation and Insulation of a Large-Power, Long-Distance Transmission System,* for which the Institute in 1921 awarded its yearly transmission prize.

Mr. Baum has grasped the importance of linking business enterprise with scientific thinking for the betterment of social conditions. As he himself says: "The best control of a utility is that which develops an eagerness and ability on the part of the company to furnish the service and an equal eagerness and ability on the part of the consumer to purchase the service."

He is the author of many electrical articles on the subject of transmission, one book entitled Alternating-Current Transformer and another, Atlas of U. S. A. Electric Power Industry. He invented the constant potential transmission system, by which the economic range of power transmission was increased to double its previous state, and large power transmission capacity was increased 50 per cent. For the past two years Mr. Baum has studied European electrical power industry, and recently completed a voluminous report on the enlargement and extension of one of Germany's largest electric utilities.

Lightning Investigation on New England Power Company System

BY E. W. DILLARD[1]
Associate, A. I. E. E.

Synopsis.—*An analysis of the surges recorded during 1927 on a 75-mi. 110-kv. double-circuit transmission line of the New England Power System is presented in this paper. The surges are classified according to cause of surge-voltage damping, extent, etc. General conclusions are drawn regarding the nature of surges and protection afforded by ground wires.*

INTRODUCTION

IN long overhead transmission systems lightning disturbances constitute the greatest hazard to service. Perfect relay operation, even if it could be maintained, does not accomplish a complete cure, for usually system surges cause difficulties to a large number of users. Increasing standards of service emphasize the necessity of studies of lightning phenomena.

In making such studies on the New England Power System, we have considered that three general classes of information should be obtained.

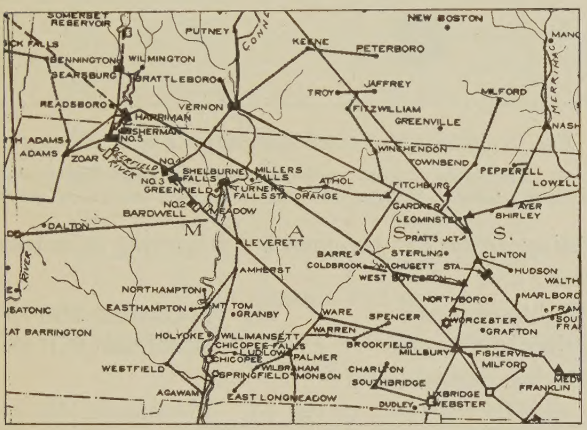


FIG. 1—PART OF NEW ENGLAND SYSTEM SHOWING HARRIMAN-MILLBURY LINE

1. Magnitude, extent, and character of lightning disturbances.
2. Protection afforded by ground wires.
3. Relative magnitude of surges of other than lightning origin.

DESCRIPTION OF LINE

In an effort to get information of this nature records have been made of the surges occurring on the 110-kv. line of this company extending from Harriman, Vermont, to Millbury, Mass., a distance of 74.6 mi. A map of part of the system showing the Harriman-Millbury line is given in Fig. 1.

This line was chosen for investigation because of its unusual construction features. The general type of construction is shown by Fig. 2. Horizontal arrangement was used to give better performance under sleet conditions, lessen the chances of arcs blowing from phase to phase, and to give a lower height of conductors above ground. A ground wire was installed over one circuit only. The characteristics of the line are:

Circuits	Two three-phase
Length	74.6 mi.
Operating voltage	110 kv.
Frequency	60 cycles
Insulator—suspension	8 disks
Insulators—strain	9 disks
Conductors	4/0 copper
Ground wires	One 7/16-in. crucible steel
Transpositions	Nine (three complete rolls)
Conductor spacing	12 and 13 ft.
Average height of conductors above ground (entire line)	42.15 ft.
Maximum elevation above sea level	2100 ft.

SURGE-VOLTAGE RECORDER INSTALLATION

Through cooperation with the General Electric Company, surge-voltage recorders were installed and operated during the summers of 1926 and 1927. There was very little lightning in 1926 after the recorders were installed. During 1927 unusually severe lightning conditions were experienced and only 1927 surge-voltage records are discussed in this paper. Surge-voltage

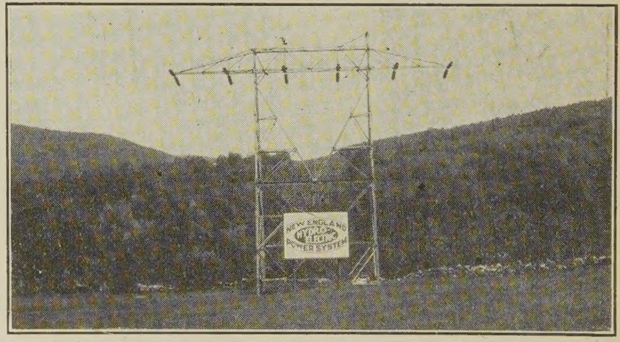


FIG. 2—TOWER ON HARRIMAN-MILLBURY 110-KV. LINE

1. Electrical Engineer, New England Power Company.

Presented at the Summer Convention of the A. I. E. E., Denver, Colo., June 25-29, 1928.

records are supplemented by operating data of this and other years.

A total of twenty surge recorders was installed. Fig. 3 shows the location of the instruments. Three were installed on the north line at Harriman, six at the first intermediate station, two at the second intermediate station, six at the third intermediate station, and three on the south line at the Millbury station. Fig. 4

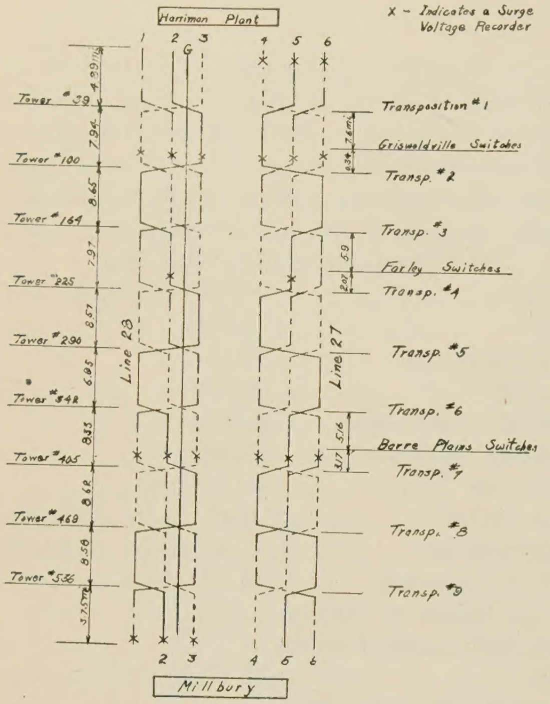


Fig. 3—Diagram of Harriman-Millbury Line

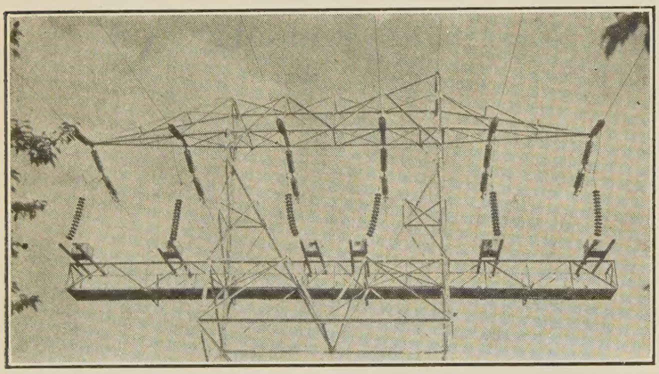


Fig. 4—Surge-Voltage Recorder Installation

is a photograph of the installation at an intermediate station. Fig. 5 shows a typical record obtained.

Results

A total of 155 surge voltages was recorded between June 6, 1927, and October 10, 1927. These may be classified according to origin and maximum recorded voltage as follows:

Lightning	104	maximum 900 kv.
Switching	29	maximum 360 kv.
Unknown	22	maximum 270 kv.

Fig. 6 shows the number of surges recorded at various voltages. Only about 20 per cent of the recorded lightning surges were above 450 kv. No surge-voltage recorder indicated a high enough voltage to cause an insulator flashover, but during this period 47 trip-outs were experienced on the line. It is believed this observation indicates high decrement of lightning voltages rather than any inaccuracy of measurement.

Fig. 7 shows the number of surges at various voltages segregated according to amount of damping. The 104

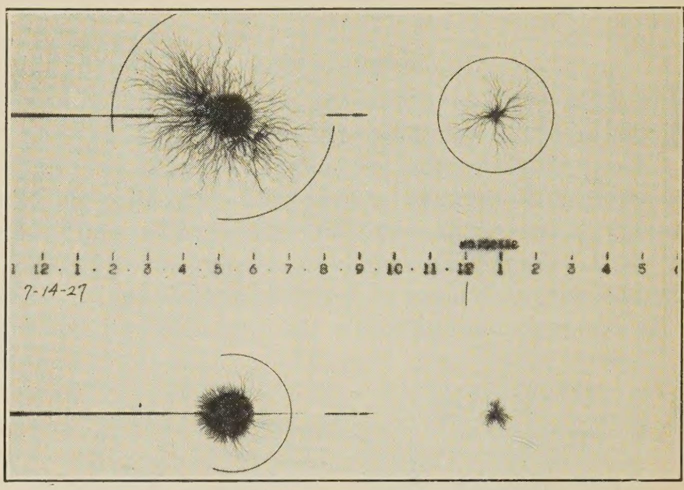


Fig. 5—Surge-Voltage Recorder Field Record

At left, large highly-damped figure from lightning, small slightly-damped figure superimposed. At right small highly damped figure from lightning.

lightning surges can be classified according to nature as follows:

Highly damped	71,	Maximum 900 kv.
Slightly damped	19,	Maximum 670 kv.
Highly damped and slightly damped, mixed	14,	Maximum 900 kv.

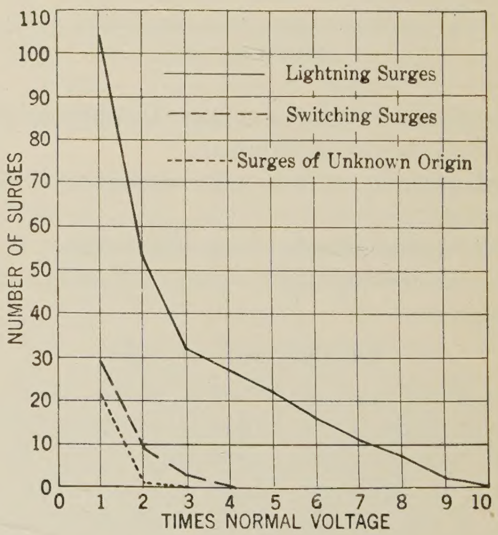


Fig. 6—Number of Surges of Different Origins which Exceed Various Times Normal Voltage Values

Cause of surge	No. highly damped	No. slightly damped	No. highly damped and slightly damped
Lightning	71	19	14
Switching	27		2
Unknown	10	12	

These results indicate a preponderance of highly damped surges both in regard to magnitude and to number. The inference to be drawn from this fact is that the surges most likely to cause flashovers are unidirectional. The origin of the slightly damped surges is not definitely known. There are indications that they are produced locally in the instrument by the potentiometer arrangement used. It is not felt that these records should be interpreted as indicating slightly damped surges on the line.

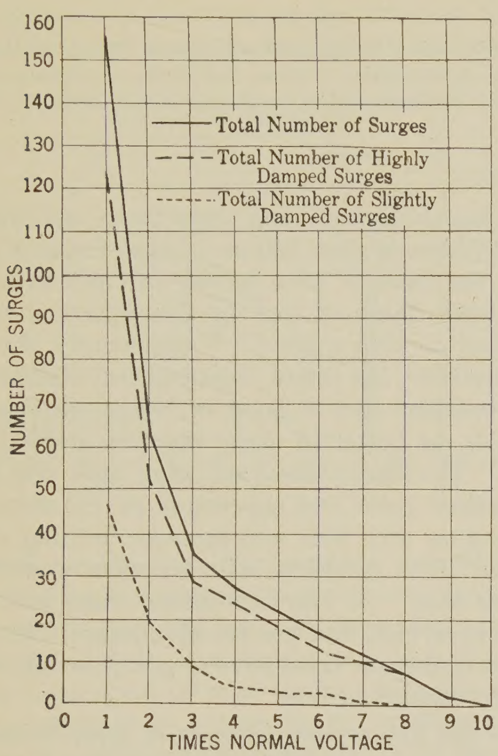


Fig. 7—Number of Surges at Various Times Normal Voltage

Protection of Ground Wire

It is not felt that the surge-voltage-recorder data in regard to ground-wire protection are particularly conclusive. Other operating data, particularly the record of flashovers, give a more conclusive indication of the value of ground wires. During the operation of the line, since 1924, there have been 57 flashovers in which only one line was involved. Forty-four of these flashovers have been on the unprotected line and 13 on the protected line. This would indicate a protective ratio for the ground wire of 3.4 to 1.

It is probable that the surge-recorder tests would have been more conclusive on this point if they had been more comprehensive. The information obtained in these tests is also confused by the fact that the lines are transposed.

Data from one of the intermediate stations, Barre, at which recorders were installed on all six conductors are shown in the following table. In order to eliminate the effect of transposition as much as possible, only those surges having their highest voltage at Barre are included as these surges probably originated near Barre

Surge Voltages Having Their Highest Value at Barre
Ground Wire is Above Conductors 2 and 3.

Surge No.	1	2	3	4	5	6
			Times Normal Voltage			
59	5.2	3.9	3.3	2.2	4.2	4.2
66	9.0	3.9	6.5	3.8	6.0	6.1
88	3.1	2.5	4.0	2.8	3.5	5.3
113	2.8	2.7	3.2	2.8	2.7	8.3
114	4.0	2.8	3.9	5.0	5.5	8.3
Average	4.8	3.1	4.2	3.3	4.4	6.4

and therefore their records were least affected by transposition. The ground wire at this point is above and between conductors 2 and 3.

It is seen that no definite conclusions as to the value of the ground wire can be drawn from these results.

Conclusions

1. On this system during the period of the investigations practically all surge voltages of appreciable magnitude due to lightning were unidirectional or highly damped and of negative polarity.

2. No switching surge of greater than four times normal was found.

3. The maximum voltage of a lightning disturbance does not seem to be impressed over more than a very limited portion of the line. More study should be given to this point.

4. The data collected by the surge-voltage recorder do not allow definite conclusions to be drawn relative to ground-wire protection. Other data from operating records indicate worth-while protection.

AUSTRIAN HYDROELECTRIC POWER DEVELOPMENT

Official statistics recently published show that during 1927 seven comparatively large hydroelectric-power stations with a mean annual capacity of at least 500 hp. each and a total mean annual capacity of 36,000 hp. were constructed. The total number of large hydroelectric-power stations constructed in Austria since 1919 has been increased by these activities to 78 with a total mean annual capacity of 178,955 hp., a turbine capacity of 367,937 hp., and a maximum annual output of 963,100,000 kw-hr.

An average of about 20,000 hp. has thus been added annually for the last nine years, and developments during 1927 were well above the average. It is reliably estimated that about $7,000,000 was invested in water-power plants and about $700,000 in high-tension transmission lines during the past year.—June 11, 1928, *Commerce Report.*

Abridgment of

Improvements in Insulation for High-Voltage A-C. Generators

BY C. F. HILL[1]

Non-member

Synopsis.—A discussion is given of the insulation problem in relation to increased size, rating, and voltages of turbo alternators, and some results of experimental studies are given showing the possibilities of improving the insulation to take care of such increases.

Mention is made of the effects of high-voltage testing and the use of hydrogen on the insulation problem, and finally, an explanation of a device for the elimination of corona formed around armature coils.

* * * * *

THE present type of turbo alternator is the result of but little more than 20 years' development; yet the changes in such machines have been frequent and striking. The result is that machines are being built so much larger in size and power output that we hesitate to predict a limit in their sizes. But indefinite increase in mere bulk or mechanical size is undesirable, transportation being already a problem. We are confronted, therefore, with the desirability, if not the necessity, of improvements in electrical features which will permit increased concentration of energy and of the various electrical features the insulation problem is discussed in the present paper.

General Discussion

While increase in voltage determines the more serious phase of the insulation problem, the insulation engineer must consider also the mechanical problem of building and winding the coil, as well as the effects of heat, temperature, and heat dissipation. The insulation problem is of course intimately related to the machine temperatures that may be used, and $I^2 K$ losses must be conducted through the insulation. Only a radical increase in insulation design will permit a decided rise in machine temperatures, a change which would be very desirable at present.

The use of hydrogen as a ventilating medium promises to be a distinct advance in the control of temperatures by allowing approximately 25 per cent increase in rating at the same temperature. This change, however, does not affect the insulation to any extent, except in so far as corona action is decreased over that experienced in the presence of oxygen.[2]

Mica Folium

As insulation, the present arrangement of mica, paper, and bond has worked out very well in turbo generators, and it may be said that this combination made the modern generator possible. The particular type of insulation combining these three, and which is considered here, is mica folium. Large sheets of paper to which the flakes of mica adhere are built with overlapping mica flakes of four or five square inches in area, sealed on with a bond. Until recently, the bond used was shellac, but lately, experimental studies have made it evident that a bond of recent development promises to be better in many respects, and has been adopted. The folium sheets are being built and baked to the desired point and are wound on the stator bar and ironed on with heat and pressure forming a solid insulation. The resultant coils are then wound into the stator slots. So far, the shellac bond has given dependable service, and has its advantages; but other properties of the new bond seem to give it an advantage for higher voltage service.

One of the undesirable features of mica folium has been the tendency to swell in the slot. The defect has its good point, in that the coil is kept tight in the slot; but it has not been expected that this property was associated with the best electrical properties. During the present study, the cause of this swelling has been definitely associated with the high volatile content from the shellac and the impervious nature of the insulation. By making a porous insulation, these vapors could escape more readily, but electrical strength would necessarily be sacrificed to do this and it is therefore desirable that the defect be eliminated by some other means. Further studies of the internal gases show that very small gas pockets exist in all laminated insulation in which internal corona[3] can take place, but although several coils from service have been examined, no effects of internal corona have been found. Any small amount of oxygen present would soon be consumed, and the effect of corona has been too small to detect. One possibility of preventing this swelling action suggests itself by removing all of the solvent and volatile content before winding the coil; dry shellac having excellent properties after once in the coil, but involves difficulties in processing. The work has been directed therefore more towards a new bond, which lends itself more readily to obtaining the desired properties.

1. Research Laboratory, Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

2. Knowlton, Rice, and Freiburghouse, *Hydrogen as a Cooling Medium for Electrical Machinery*, Trans. A. I. E. E., Vol. XLIV, 1925, p. 922.

Presented at the Regional Meeting of the A. I. E. E., District No. 2, Baltimore, Md., April 17-19, 1928. Complete copies upon request.

3. J. B. Whitehead, *Gaseous Ionization*, Trans. A. I. E. E., Vol. XLIII, 1924, p. 116.

Power Losses

In all high-voltage apparatus, an important property of the insulation is that of power losses. By this, we have reference to the losses produced by the oscillation of charges within the dielectric itself, and manifesting themselves as heat. These have little effect upon the total efficiency of the machine, but although the actual watts lost is not so great, they are concentrated in the dielectric, raising its temperature somewhat. Continued curing by heating tends to lower these losses by removal of more or less volatile material. Solvents would therefore be expected to play an important part in the production of these losses, and two possibilities suggest themselves in solving the problem; either to reduce the solvent to a minimum, or to use a solvent which has better dielectric properties in itself, or both. The ideal bond would be one which could be melted and applied at temperatures well above operating temperatures, using no solvent whatever. So far, the ideal bond has not been found, but results show that a large reduction in losses is possible by a choice of bond having low losses in itself and being soluble in a solvent of low loss, with a reduction of this solvent to a negligible quantity in the finished insulation.

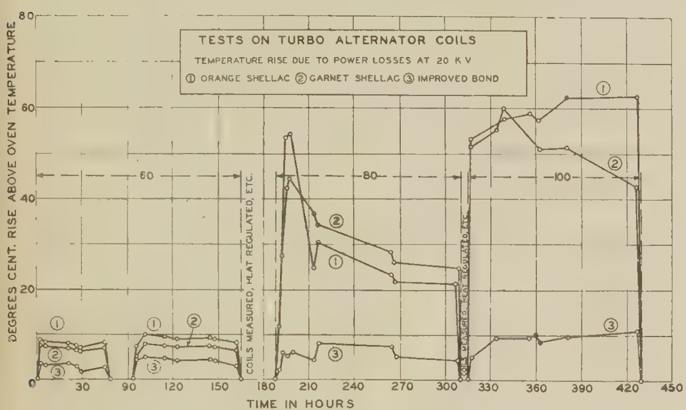


Fig. 1

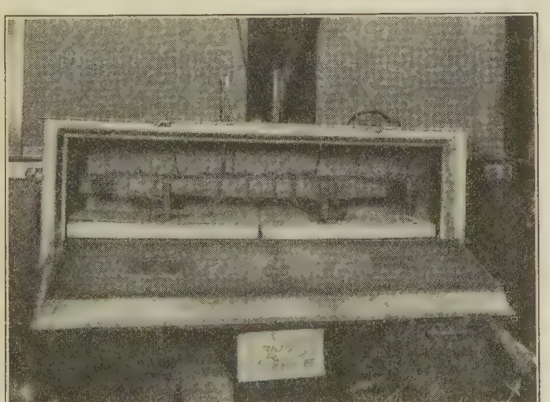


Fig. 2

The curves of Fig. 1 show comparative data on standard mica folium with shellac bond, and with a bond recently developed along the lines mentioned above. Since the actual loss in watts is of little importance, and the temperature rise of greater importance, values of the latter are used as ordinates in the data. The abscissa is the time in hours that the voltage of 20 kv. is applied to an insulation design for 13,000-volt operation. Attention is directed especially to the importance of power losses in case higher voltage stresses are imposed. As a general rule in a 13,000-volt machine, approximately 8000 volts exists across the insulation. More than twice that stress is applied in this case, and it is evident that the losses in the standard folium are too high; on the other hand, the improved bond withstands the voltage readily. Possibly considerably higher temperatures could be used on the latter without sacrificing all the gain over standard folium. The curves also give an idea of the rise in losses with temperature of the insulation.

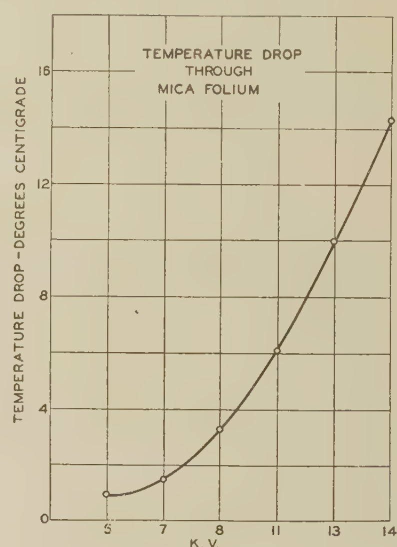


Fig. 3

Fig. 2 illustrates the apparatus used in the study of the coils, temperatures being taken by thermocouples inserted in the hollow conductors of the bars. Machine temperatures were imitated by means of a thermostatically controlled oven and the slots by means of metal clamps. Gaps between clamps give the effect of vent ducts, gaps of ½ in., 1 in., and 7 in. being used.

The curve of Fig. 3 is a characteristic one representing the variation in losses with voltage stress and brings out the fact that the losses increase faster than the voltage. Assuming the equation

$$\text{loss} = E^n$$

n is found to be almost exactly equal to two at 5000 or 6000 volts, but increasing gradually to approximately three, near the upper end of the curve.

As mentioned above, the swelling of coils due to the solvent is a factor to be considered. Comparative tests on the two bonds in the present case are found in Fig. 4 for a one-half in. gap at 80 and 100 deg. cent. machine temperature. Curve 1 is for a standard shellac

folium, while No. 2 is that with the new bond. The processing was done in the shop to make the test comparable. It is evident that considerable progress has been made, although even a more complete removal of the solvent may be possible. If the surface layers could be preserved as will be discussed later, and the coil originally wound tightly in the slot, the tendency to remain tight, rather than loosen, is an advantage.

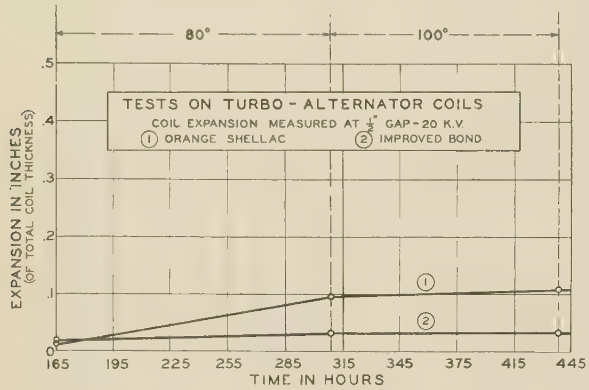


Fig. 4

After some further tests were made, showing definitely the losses due to the volatile part of shellac, a coil with the improved bond was placed in a 100 deg. cent. ambient and 30,000 volts applied until temperature equilibrium was obtained (see Fig. 7). While some curing had probably occurred, the coils were tightly clamped during the test and this effect was believed to be small. 13,000-volt insulation was used in the test. Up to the present, power losses have not been considered in turbo insulation, but if higher voltage stresses are used, such losses must be considered, and it is believed that the results of the present study indicate that an increase in stress is practical, thus making possible a considerable increase in generated voltage.

One very important feature of the new bond is the flexibility of the folium as compared with shellac; and it is found possible to use several extra layers of mica, which is desirable as long as the coil is good mechanically.

Breakdown Tests

While it is not recommended that higher voltage stresses be used until necessary, it is felt that the present studies warrant considerable increase over present stresses. In this connection dielectric strength under short-time voltage applications is of importance from the standpoint of both resistance to surges and to overvoltage testing. It will probably also be of considerable interest to engineers to know what the actual safety factor is for such insulation.

Three coils of four-foot length designed for 22,000 volts using the improved insulation were tested by means of six-inch tinfoil electrodes near the middle of the coil, the whole immersed in oil to prevent flashover. On a continuous rise voltage test the three coils flashed over at 150,000, 170,000 and 165,000 volts but did not puncture. A coil of 20-ft. length was then tried in air and flashed over at approximately 165,000 volts on three tests. It is not the dielectric strength, therefore, but the power losses that will determine the upper limit of operating voltage.

Testing Voltages

With higher operating voltages, overvoltage tests may become a problem. During the present study qualitative data have been obtained which show there is some danger at least of damaging coil surfaces or a few surface layers by static discharges. On the other hand, a damping effect can be used to eliminate part of the danger at least by utilizing the action of a corona-eliminating device mentioned below.

Corona Elimination in Turbo Stators

The phenomenon called corona made its appearance in machines as soon as voltages were developed of the order of 5000 or 6000 volts from conductor to ground. The evidence of its presence is furnished by the odor associated with ozone, which is a product of the action of corona on the oxygen of the air and it is visible to the eye under favorable conditions. While the coil is mechanically tight in the slot, there still exists some very small air-gaps due to manufacturing tolerances and irregularities of the surfaces in contact and these minute gaps are over-stressed, producing corona.

So far, all evidence points to the fact that the actual danger from corona is slight, but there are some reasons why it should be removed if possible, as, for example, the coil could be held rigidly in the slot without permitting expansion as occurs when the slot liner and wrapper are eaten away. This will eliminate also the uncertainty in the minds of some designers and operators and finally may help to reduce effects of testing voltage. As much as 15 years ago, engineers began to feel uneasy

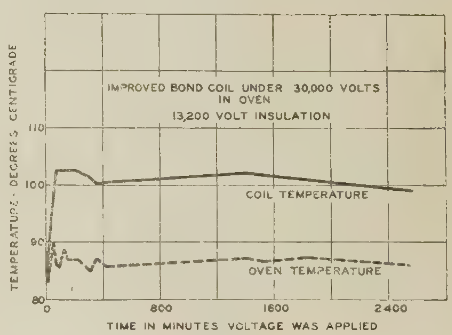


Fig. 7

about its effects on insulation and the problem of its elimination was considered. It was evident that all that was necessary was to remove the voltage stress in the air-gap, which could be done by bringing ground potential to the surface of the solid insulation by making the surface a conductor. Accordingly, metallic paints and tinfoil were tried and actually put into some machines. The tinfoil was applied with an outer covering of cotton tape, and was grounded at but one point; otherwise, the steel laminations would be short-

circuited. The paints were usually too high in resistance to be efficient. Along with the difficulties of applying and the fact that corona in mica-insulated machines without this kind of protection did little damage, the problem was dropped as mica was generally used. However, it has seemed more and more desirable to remove the corona if such could be done without too much difficulty, and with the possibility of higher generated voltages, the problem will become even more important. For this reason the present study has been extended to include the problem.

Some features of a solution of the corona problem are self-evident. The conducting film to be placed on the coil must be continuous and adhere to the insulation surface. Further, the resistance of the film must be large enough to prevent eddy currents, and in case of grounding at more than one point, should also be high enough to prevent circulating currents. Metallic films in general fall in a class with resistances too low to be used, and at best could be grounded at but one point. In case this ground was broken most of the effectiveness of the film might be lost. For this reason, a film of resistance sufficiently high to permit of more or less continuous grounding throughout the slot is ideal. The upper value of resistance is determined by a maximum value which will permit a charging of the condenser between the conductor and film to the full potential of the machine during a half cycle. Calculations show that the resistance per unit length of coil can be as much as a megohm even for relatively few grounding points. On the other hand, a minimum of 1000 or 2000 ohm per in. length of coil is sufficient to

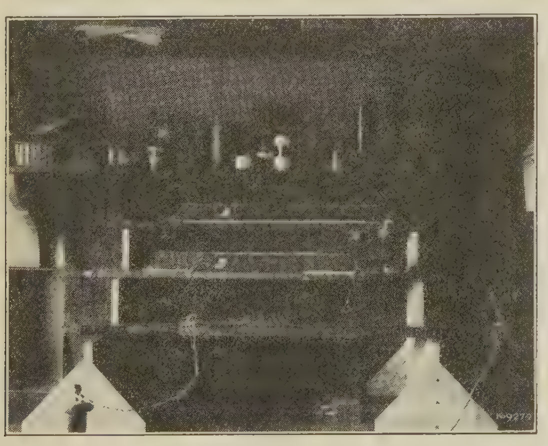


FIG. 8

A = No attempt at elimination
B = Effects of graphite paint
C = Complete set-up

eliminate eddy and circulating currents so that a wide range of workable resistance exists.

One special graphitic paint has been found which is practical and can be used throughout the slot allowing continuous grounding if desired. Corona exists at the end of this layer, however, and a special device, extending a few inches beyond the end of this layer to damp out the end effect, consists of a high-resistance, 100- to 500-megohms per inch length of coil, electrically connected to the graphitic layer. Capacity currents flowing out into this high resistance can be made to damp out or lower the voltage along the damping layer, so that the voltage at the end is below the ionizing voltage of air. Fig. 8 gives an idea of the effectiveness of the complete device under 30,000 volts.

Four or five inches of this damping layer will take care

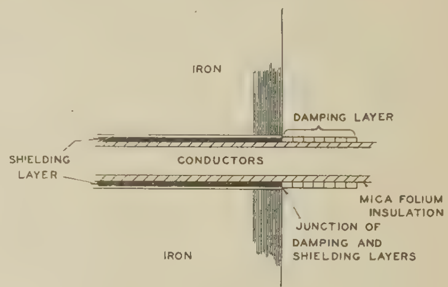


FIG. 10

of 30,000 volts. Fig. 10 is a sketch of the arrangement at the end of the slot.

CORONA IN END WINDINGS

A problem which has caused some discussion in the past has to do with the formation of corona on the metal parts of the structure bracing the end windings. So far, this problem has not been of much importance for the type of bracing used with mica folium coils, as enough insulation could be used between the metal parts and the coils so that operating voltages could produce at most only a soft, harmless corona. The question may be revived, however, with voltage increases in machines, but the problem in any case cannot be considered serious, since types of bracing can be used in which extra insulation can be added to bring the stresses in the air-gap below the corona point. It is a simple matter to calculate the air-gap stresses on the basis of the insulation thickness and dielectric constants or, in other words, to calculate the insulation thickness necessary. The metal parts in such cases are to be assumed to be at ground potential;—that is, at the average of the coil potentials,—thus guaranteeing that no high voltages will be built up across the insulation at any point. From this point of view it is necessary to ground all metal parts, but in general this is more important, in that it permits better mechanical features.

Reference was made above to the effects of corona in hydrogen on insulation. The usual deterioration of organic material in the presence of air under corona is due chiefly to oxidation. With hydrogen, this effect will be absent and so long as the arc temperatures are not too high the bad effects usually associated with corona should disappear where they actually strike the insulation. Even intense corona has been found to have but slow effect under short tests of a few weeks.

For the same reason, the absence of oxygen protects

laminated insulation from the action of internal corona.

SUMMARY

A summary of the above discussion may be made as follows:

1. That as generated voltages are increased, it may become necessary to use higher voltage stresses in volts per mil thickness of the insulation, which in turn may necessitate the use of a lower power factor material in order that excessive heating be avoided.

2. That a very decided improvement in this property can be obtained for mica folium by a choice of bond containing only a negligible amount of a low loss solvent or other volatile material.

3. That the reduction of the solvent decreases the tendency of such coils to expand, and it has been found that the swelling is reduced to a small fraction of that of older insulations.

4. That the factor of safety to puncture as determined by continuous rise voltage tests is considerably more than is ordinarily considered necessary for most applications, and that the results indicate higher stresses on mica folium could be used.

5. That so far the effects of corona not having been serious and in no case the mica affected, yet to protect the organic surface of the coil, it may be desirable to eliminate corona at present voltages as well as at higher voltages. In hydrogen, it will not be so important.

6. That a method of eliminating corona on armature coils has been devised which is believed to be practical.

Operating Experience with High-Speed Oil Circuit Breakers

BY B. F. BARDO[1]

Non-member

Synopsis.—This paper outlines the experience of the New York, New Haven and Hartford Railroad with three high-speed oil circuit breakers which were installed in 1925 to serve an electrified branch line carrying freight and passenger traffic, both local and through.

Satisfactory operation of paralleling commercial communication circuits, as well as of its own, presented an immediate problem, which after study outlined in the paper, finally yielded, and the answer, in part, was high-speed circuit breakers. The electrical and mechanical characteristics of these are set forth in detail and illustrated.

A number of tests of the circuit breakers and communication circuits made by short-circuiting the 11,000-volt lines on the branch showed currents up to 3000 amperes, and openings in from one-half to one and one-half cycles, with satisfactory operation of commercial and railroad communication plant.

A detailed record of the service operations of the circuit breakers along with a statement of failures is given. It is proper to say that the latter were more numerous in the early days of their use than they have been in recent months, and that a number of the faults are chargeable tot he railroad's urgent need for the equipment, thereby considerably limiting the development and testing time desired by the manufacturer.

While it was not discussed in detail in the paper it goes without saying that in the design and installation of the circuit breakers safety was a paramount consideration. The illustrations will provide an index of this in the general arrangement of equipment, and also in the screen placed horizontally around the structure at the floor level to prevent curious small boys from climbing in to investigate.

CHARACTER OF SERVICE AND ELECTRIFICATION

BEFORE discussing in detail the New Haven Railroad's experience with high-speed oil circuit breakers, it will be of interest to review briefly the reasons for their installation.

In the latter part of 1924, decision was made to electrify the Danbury Branch, comprising 23.82 mi. of main, along with 5.1 mi. of passing or side track between South Norwalk, Conn., in the New Haven's electric zone, and Danbury, Conn. The service at that time consisted of an average of six passenger trains, two through freight trains, one milk train, and one local freight train per day in each direction. The system of electrification was to be essentially the same as that in use on the main line, between New York and New Haven, Conn., namely, 11,000 volts, single-phase, 25 cycles, using an overhead contact wire and track rail return. A schematic diagram of the distribution system, as finally adopted, is shown in Fig. 1.

COMMUNICATION FACILITIES

On the branch to be electrified the New Haven had open wire communication circuits used by the Western Union Telegraph Company and itself respectively. Furthermore, on private property immediately adjoining and paralleling the company's right-of-way for nearly half of the distance and on public highway for the balance of the distance was a commercial open wire telephone line, this being more or less spread out in the various towns along the way. Therefore, an immediately important problem was to decide how best to provide for satisfactory operation of paralleling commercial and its own communication circuits, and at the same time not make the electrification itself too

1. Supt. of Elec. Transmission, N. Y., N. H. & H. R. R. Co., New Haven, Conn.

Presented at the Summer Convention of the A. I. E. E., Denver, Colo., June 25-29, 1928.

involved, from an operating standpoint, or too expensive from a maintenance standpoint.

Studies Made

Various schemes were studied involving the use of reactors in the trolley and feeder circuits at South Norwalk (see Fig. 1), along with booster transformers, balancing transformers, and supplementary return circuit, independent of the running rails; the induced

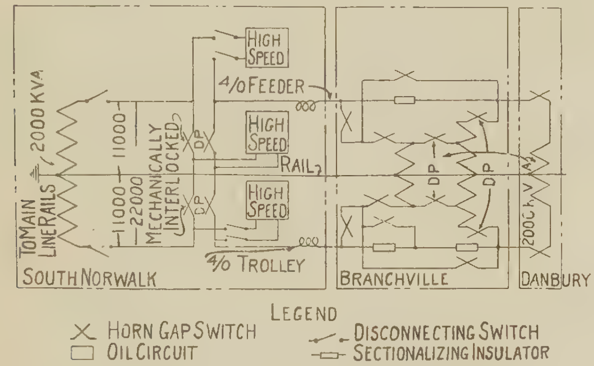


Fig. 1—New York, New Haven & Hartford Railroad Company, Danbury Branch

Schematic diagram of electric power distribution

voltages and other effects in each case being based upon the average duration of short circuit as determined by oil circuit breakers standard elsewhere in the electrified zone. The results of these studies indicated that the electrification and the communication circuits could be so designed that they would operate satisfactorily, using existing standard circuit breakers to interrupt short circuits, but this involved the installation of a number of series booster transformers, which were not desirable from railroad operating point of view.

At this point the installation of high-speed oil circuit breakers at South Norwalk was proposed, with the understanding that while they would not decrease the magnitude of the voltage induced in the communication circuits, yet by virtue of their quick operation, they would materially reduce interference in both railroad and commercial communication circuits. It was decided that circuit breakers of this kind would be more desirable than booster transformers, and therefore the following program, satisfactory to all interests, was adopted:

a. Place paralleling commercial communication circuits in cable on the public highway.

b. Install adequate drainage on communication circuits on railroad right-of-way—Fig. 2.

c. Install high-speed oil circuit breakers at South Norwalk together with three-ohm reactor, in trolley and feeder circuits respectively, and auto balancing transformers at South Norwalk, Branchville, and Danbury,—the one at Branchville to have incorporated with it an auxiliary unit capable of raising the voltage approximately ten per cent. See Fig. 1.

Description of Circuit Breakers

The matter of deciding to use high-speed oil circuit breakers proved to be more simple than procuring them. Some development work had been done, but the circuit breaker was not then in commercial production, and considerable pressure was required to convince the manufacturer that three should be built. This, however, was finally arranged, and they were built early in 1925.

Each of these carries a normal rating of 800 amperes at 16,500 volts, 25 cycles. The maximum interrupting capacity approximates 35,000 amperes. Direct current is used for control normally at 250, but with a standby supply at 500 volts. The tripping operation is started by solenoids, of which there are two, connected in parallel on the lower, and in series on the higher voltage. The actual tripping work is done by spiral springs, these being compressed during the closing operation by a 110-volt, 25-cycle, single-phase motor operating through a train of gears. The circuit-breaking mechanism is in the shape of an inverted letter "T," with a blowout coil, in series with the circuit to be broken, on each stationary contact. The entire assembly is immersed in insulating oil, and enclosed in a substantial sheet steel cylindrical tank, suitably vented. Two condenser type bushings, each terminating in a removable stationary contact within the tank carry the current, and the whole is supported by four angle steel legs to which are bolted cast iron feet. There is an individual current transformer of the outdoor type for each circuit breaker, which is directly connected to an overload coil, also for

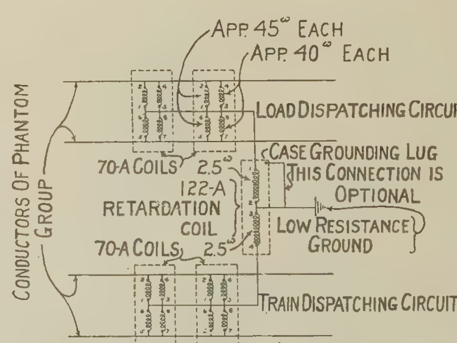


Fig. 2—Danbury Branch—Communication Circuit Drainage

each circuit breaker. Irrespective of the location of the short circuit, whether on trolley or feeder, it is desirable to open both trolley and feeder circuit breaker, and this is accomplished by auxiliary contacts on each overload relay so connected that when one circuit breaker opens the other will immediately follow, thus clearing the line.

Installation

Three circuit breakers were installed on a steel platform 27 ft. by 10 ft., with reinforced concrete house

directly underneath, and change-over horn-gap switches directly overhead. Reference to Fig. 1 will show that any of the three circuit breakers may be used in any combination, two at a time. Fig. 3 shows an elevation of circuit breakers as installed, and Fig. 4 of the entire substation of which they are a part.

Communication Line Protection

The method of applying drainage to communication circuits is as follows: The physical circuits are drained

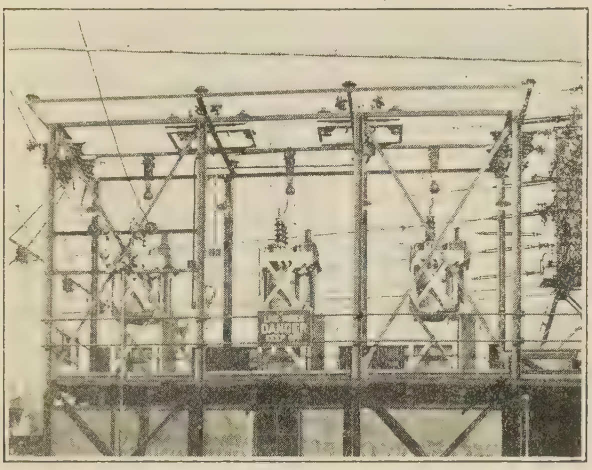


Fig. 3—High-Speed Circuit Breakers, South Norwalk

by two No. 70-A repeating coils so connected that both primary and secondary windings are in multiple. The midpoints of these windings are then connected to

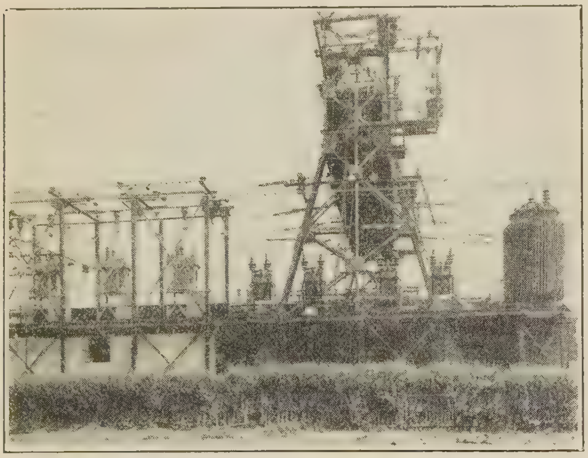


Fig. 4—Substation at South Norwalk

ground through one winding of a No. 122A coil, which acts also as a drain on the phantom circuit. A combination such as this was installed at each end of the branch and at six intermediate points approximately uniformly spaced from each other.

Tests

In the early part of October 1925 a series of tests was made jointly by the American Telephone and Telegraph Company and the New Haven to determine the extent to which the high-speed circuit breakers, as well as the communication line drainage, etc., contributed to satisfactory operation. Oscillograph records of these tests were made, three of which are reproduced here. They are:

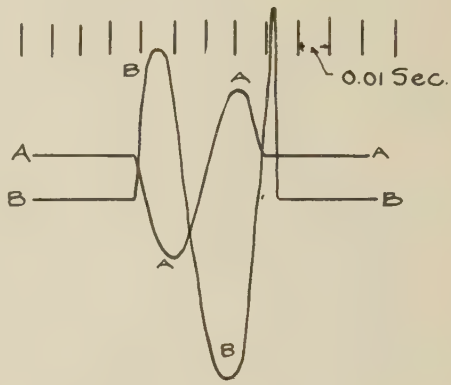


Fig. 5—Short Circuit at Danbury—23.8 Mi.

A. Trolley current—maximum 1000 amperes
B. Volts across drainage at South Norwalk—maximum 48.7 amperes

Fig. 5—A short circuit at Danbury, 23.8 mi. from the oscillograph, the latter being at point of supply, South Norwalk. The circuit was opened in one cycle (1/25 sec.) and the current reached a maximum of 1000 amperes.

Fig. 6—A short circuit at Wilton, 7.4 mi. from South

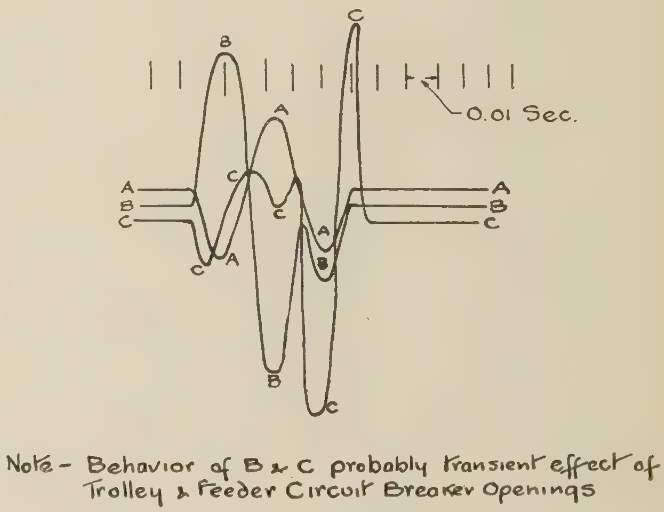


Fig. 6—Short Circuit at Wilton—7.4 Mi.

A. Feeder current—maximum 560 amperes
B. Track current—maximum 685 amperes
C. Induced voltage—maximum 1420 amperes

Norwalk, showing an opening in one and one-half cycles at a maximum 540 amperes.

Fig. 7—A short circuit at South Norwalk, one-half mile from the oscillograph, showing the circuit open in one-half cycle, the maximum current being 3030 amperes.

Circuit Breaker Operation

Considering the three circuit breakers as a group, it may be noted that since being put in service in July 1925 the operation has been as follows:

Total number of operations on grounds......	717
Ave. number of operations on grounds per circuit breaker........................	239
Total number of other operations to 1-1-28...	750
Ave. number of other operations per circuit breaker..............................	250

The circuit breakers have not operated faultlessly and therefore the third, or so-called spare circuit breaker, has been of real use, but this was to be expected. There has been on the circuit breakers as a group, since their installation, a total of 25 operating failures distributed as follows:

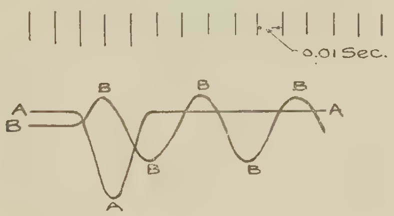


Fig. 7—Short Circuit at Norwalk—0.5 Mi.

A. Trolley current—maximum 3030 amperes
B. Induced voltage, S. N. E. Tel. Co.—maximum 180 amperes.

Trip coils....................	5
Mechanical parts............	5
Closing motor................	2
Overload relay................	1
Indicating switch............	2
High-tension terminal........	1
Unknown....................	9
Total..............	25

Of the above failures those due to mechanical causes have been most difficult to find. Adjustment in length of operating rod had to take into consideration proper sequence of events as between main and auxiliary contacts, along with irregularities on the main contacts due to arcing. If this operating rod length was not correct within fairly close limits the circuit breaker would not close and latch, although it would open satisfactorily. The forged steel spiral-spring ends in the opening mechanism received severe punishment and had to be made heavier. Likewise the foot castings on the legs had to be made of steel instead of cast iron, and the indicating switch operation had to be made somewhat more positive. In general the mechanical difficulties have been reflections of the very high speed of operation, with resultant high starting and stopping stresses.

On the electrical side trip coil failures predominated, due partly to the design of the terminals, and partly to the fact that for some reason the tripping circuit did not open. The tripping current, particularly at 250 volts, is relatively high, and if it is not interrupted as soon as its work is done one can look for trip coil difficulty. The overload relay failure was due to a ground on one of its leads caused by insulation deterioration which in turn was due to heat from adjacent d-c. tripping circuit arc. Barriers have eliminated the possibility of further difficulties due to this source. The motor failures were such as are sometimes found in motors of this nature and involved adjustment of short-circuiting device and cleaning of commutator.

In general, the statement is justified that most of the faults uncovered by our operation would not have appeared if the manufacturer had been given more time to develop the design and test it completely before installation.

Operation of Communication Circuits

It may be of interest to note that the program outlined in paragraph three, parts a, b, and c, has resulted in satisfactory operation to commercial as well as railroad communication circuits.

Acknowledgment

The writer desires to acknowledge kind assistance of Messrs. H. A. Shepard, general superintendent of electric transmission and communication department, S. Withington, electrical engineer, as well as his assistant, H. Brown, and A. R. Belmont, communication engineer.

STEAM DATA DEVELOPED BY BUREAU OF STANDARDS

The properties of steam have been studied with respect to pressures used in engineering, turbine efficiency and related fields. According to the research expert who is now conducting cooperative investigations on the subject it is expected that the new data being developed by the Bureau of Standards, will be more reliable and precise than any heretofore attained. Also according to the statement, Congress gave the Bureau of Standards the specific function of determining the properties of materials and physical constants where accurate values are needed. Among the researches in this field is the cooperative research on properties of steam now being conducted as one of the fundamental problems.

The recent increase in steam pressures used in engineering and the high efficiencies attainable in modern turbine installations call for data as accurate as are attainable. Such data are essential to further advance in steam engineering and the experimental investigations are scientifically planned to give reliable data.

When it became obvious that the enactment of the Swing-Johnson Bill for the development of Boulder Canyon could not be brought about in the last session of Congress, a resolution was adopted directing the Secretary of the Interior, with the advice of the President, to appoint a board of five eminent engineers to go further into the feasibility of the Boulder project. This board had not been appointed up to June 15, but early action is expected when Secretary Work returns July 1.

Abridgment of

The Planning of Telephone Exchange Plants

BY W. B. STEPHENSON[1]

Non-member

Synopsis.—This paper discusses procedures followed in planning future extensions to telephone exchange plants to care for increased demand for telephone service. An outline is given of the methods employed in forecasting future demand for telephone service and in determining the most efficient design of the plant to meet the service requirements. The uses made of engineering comparisons in solving the economic phases of various kinds of telephone engineering problems are discussed, with particular reference to location and size or extent of major items of plant as well as the time when they should be ready to give service. Emphasis is placed upon the importance of those factors less readily evaluated, such as service factors, practicability from a construction and operating standpoint, flexibility, etc.

* * * * *

TELEPHONE engineering involves many widely varying problems. Among these is the design of the various component parts of the telephone plant. This includes the design of central office buildings, the design of switching and power equipment to be housed in these buildings, the design of the trunk cable system with any loading necessary in order to connect these buildings, and the design of the distribution system. The distribution system includes, of course, the conduit, pole lines, feeder cable, distributing cable, house cable, etc., necessary to reach the subscriber's premises and connect his station equipment with the switching equipment in the central office.

Before the building can be designed in detail, however, determinations must be made as to whether the building should be built at all, where the building should be located, when it should be ready for occupancy, what area will be served by the building, and how much equipment must ultimately be housed in the building. Before the equipment for any particular building can be designed, we must know what type of equipment should be used and about how much business will be handled on this equipment. Before the trunk plant can be properly designed, we must know our future plans for increasing or decreasing the operating centers in a city, how much business will be handled on this trunk plant, and the economic allocation between transmission loss in the trunk plant and the transmission loss in the distribution plant. Before the distribution plant can be designed, we must know our future plans for serving the area involved. In other words, it is evident that a large amount of broad preliminary planning must be done before the detailed design of a telephone exchange plant can be undertaken.

It is the purpose of this paper to give a general idea of the methods now in use in this preliminary planning. The discussion will be confined to the exchange plant problem for the larger towns and will not go into the toll plant problem.

The first step in planning a telephone exchange plant for a city is to determine how much business will be cared for. An estimate is made of the population of the city some 20 years in the future and also for periods of about 6 and 12 years. From these data, an estimate is made of the number and location of telephone stations and lines which will be in service 6, 12, and 20 years hence.

It has been found that the various parts of the city vary widely as a market for telephone service. One of the first steps in making a survey is to divide the town up into so-called market areas or areas which display somewhat the same economic characteristics.

Field survey men then visit each block in the city. They make a record of all existing business and residence subscribers and the class of service which they take. They also record all businesses and residences which do not have service. After these surveys are completed, summaries are made which give very detailed information on the present market conditions for telephone service in the city.

Periodic estimates are made of the population of the United States, taking into account emigration, immigration, and excess births over deaths. This estimate is later broken down into states and into cities. Based upon the above estimate, estimates are made of the city in question for the future periods which take into account not only local conditions but national trends as well.

From the estimated future population and the estimated number of persons per family the number of families for the future is obtained. Based upon the knowledge of the city which was obtained in the survey and the relation between residence and business service, an estimate is made of the number of business stations. The location of these stations is also estimated from data which were obtained at the time the survey was made.

Fig. 3 shows the estimated lines for a typical city for 1947, each dot representing ten lines.

The next step in planning the exchange plant is to determine the number of operating centers required. If many operating centers are used, this will decrease the cost of the subscribers lines but will increase the central office equipment, trunk and building costs. On the other hand, if fewer centers are used,

1. Southwestern Bell Telephone Company, St. Louis, Mo.

Presented at A. I. E. E. Regional Meeting of Dist. No 7, St. Louis, Mo. March 7-9, 1928. Complete copies upon request.

this will increase the cost of subscribers lines but will decrease the other costs.

Fig. 4 indicates the present as well as future conditions for an assumed problem. Let us assume that the X and Y areas are served by new dial-type equipments housed in new buildings. Careful study was made before these operating centers were provided and it is safe to assume, therefore, that these centers will remain in their present locations for many years to come. Let us assume, however, that both the Z and M centers have manual equipment and have been in service for many years. There is no operating center in the A area, this being served at present from the X center.

FIG. 3

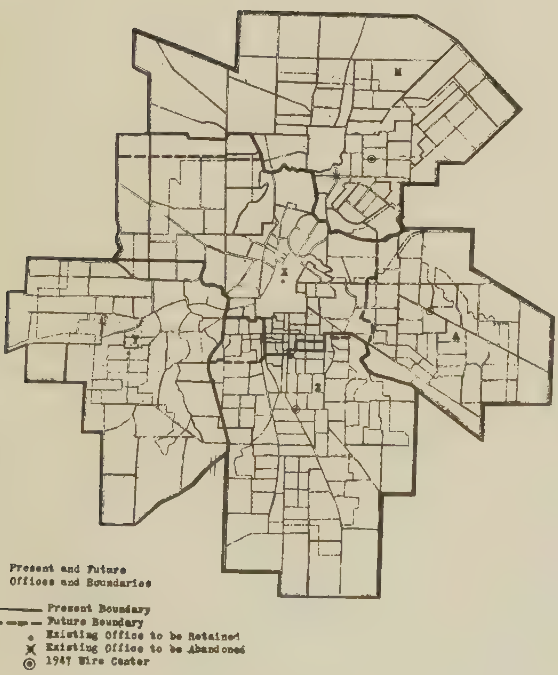
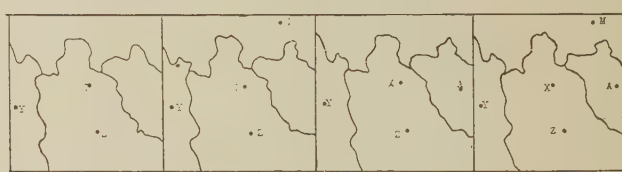


FIG. 4

In order to determine the best arrangement of operating centers, various trial arrangements are assumed. Certain costs involved in serving the city at the 20-year period in the future are calculated for these trial arrangements. All these costs are on an annual-charge basis.

Fig. 6 indicates the trial arrangements which we might assume for our problem. It is necessary that these trial arrangements be chosen with great care. The comparison of the results of the various plans must give a direct comparison of the results of some possible arrangement with some other possible arrangement; in other words, each plan must differ from some other plan by one variable only. It will be noted that Plan No. 1 assumes a center at each of the X and Y locations and in the Z area. In Plan No. 2, a center has been added in the M area. A center has been added in the A area in Plan No. 3. Plan No. 4 assumes centers in both the M and A areas.



PLAN I	PLAN II	PLAN III	PLAN IV
3 Centers	4 Centers	4 Centers	5 Centers
7 Units	7 Units	7 Units	7 Units

FIG. 6—1947 COMPARISON

The above arrangements are compared as regards annual charges for each of the following items:

Subscribers' lines
Trunks
Central office equipment
Maintenance labor
Land

The cost of the subscribers lines will decrease with the addition of each new center. The cost of trunks, central office equipment, maintenance labor, and land, however, will increase with each added center.

Let us assume that these four plans have been worked out and that Plans No. 2 and 3 are each more economical than Plan No. 1 and that Plan No. 4 is more economical than either Plan No. 2 or Plan No. 3.

These cost calculations are based largely on being able to construct an ideal plant in 1947 with no penalties due to the plant now in service, an obviously impossible condition. The results of these calculations, therefore, can be taken only as a broad general indication of the best method of serving the town.

It will be necessary to study each major move individually, with these results in mind. There is no operating center at present in the A area and the assumed results of our cost studies for the 20-year period indicate that it might be possible to realize some economies by opening a center in this area at some

future date. It is known from past experience that in general the best time to open a new center in an area is the time at which it would be necessary to make some major move if the center were not opened. Let us assume that the feeder cables serving the *A* section are located in conduit and that the last duct will soon be used. It would be necessary to reinforce the conduit the latter part of 1928 and place additional cable if we continue to feed the section from the downtown building. The question immediately arises as to whether it would be better to open an *A* center in 1928 rather than make this expensive conduit and cable addition.

Reference is made to the estimated telephone development in the *A* and *X* areas for the 6-, 12- and 20-year periods. Based upon this development, an estimate is made of plant of the various classes required in both the *X* and *A* areas between 1929 and 1947, both with and without an *X* operating center. The annual charges and operating expenses involved in the two plans are calculated on a present-worth basis as indicated in the table below.

PRESENT WORTH 1929-1947

	Plan I Operate from "X"	Plan II Open New Office
Aerial cable	\$ 55,966	\$ 45,812
Underground cable	187,243	41,706
Underground conduit	59,868	——
Salvage on displaced plant	−26,559	−42,521
Building including house service	28,922	108,678
Land	——	4,306
Central office equipment	334,998	477,597
Excess maintenance	——	69,883
Number changes	2,184	14,500
Traffic saving	——	−8,496
Excess inter-office trunks	——	10,764
Total	642,622	722,229
Excess		79,607

NOTE: The above does not indicate the total cost of serving the area, of course. The cost of much of the plant which will be required under either plan, has been omitted as being common to both plans.

The above summation indicates that in so far as the various factors can be evaluated, the cable and conduit should be reinforced rather than a new center opened.

The annual charges both with and without the *A* center were obtained for 1928 and 1946 and were plotted upon a graph as indicated in Fig. 7. It is appreciated, of course, that this annual charge will not be a straight line between 1928 and 1947 but will be irregular due to the periodical additions of plant. The straight line, therefore, is only a general approximation of the actual conditions.

Telephone central office buildings are built as nearly as possible on their "wire centers." A wire center is that location for an operating center at which the cost for subscribers lines and trunks will be at a minimum.

The problem in the *Z* area is somewhat more complicated than that of the *A* area. This is due to the fact that there is a building in the *Z* area housing manual equipment. This building is a considerable distance from the wire center for future development. The problem in the *Z* area might be stated specifically as follows:

1. The *Z* area is served from one building which is considerably off the wire center for future development. The building houses one manual unit which will soon be filled, making it necessary to provide some major relief.

2. The preliminary indications are that the *Z* area should be served from one building in the vicinity of the wire center, overlooking for the moment the factors involved in making such a move.

We shall have to answer the following questions for the *Z* center:

1. When the new equipment unit is started, should this unit be located in an addition to the present building to conserve existing plant, or should a new building be erected near the wire center for the purpose of decreasing future investments in plant to care for future growth?

2. Should the new unit be of the manual or dial type?

3. In case the new unit is to be of the dial type,

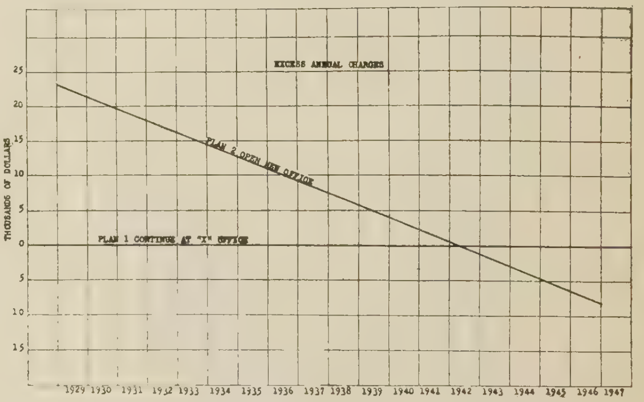


FIG. 7

should enough equipment be installed for growth only or should enough be installed to displace the manual unit?

It will be necessary to consider several possible construction programs for this area. Having determined the factors involved in the various programs, each one of these programs is analyzed carefully. Possibly one or more can be eliminated due to practical considerations and careful cost studies may eliminate other programs from an economic standpoint. Taking all factors into account, one program is finally determined to be most favorable to meet the needs of the particular situation.

The above discussion may have given the impression that the economics of the problem are given undue consideration. This is not the case, however. Every construction program must be considered from many other angles as well as from an economic angle. For

example, if one program would give better service to the public than another program, the program involving the better service will receive very careful consideration even though this program might not be quite as attractive from an economic standpoint as other programs. Some programs require large amounts of capital, labor and material, and it is obvious that the programs should be spread out to best advantage over a period of years.

Any program must be considered carefully to be sure that it is thoroughly practicable from a construction and from an operating standpoint. It is also very desirable that existing plant be used to best advantage. When such plant is in good condition and would continue to give good service, it is generally desirable that it be retained.

It is very important that all programs for the future be developed in such a manner as to give a maximum of flexibility. A plan must be such that suitable adjustments can be made economically in the event that the growth performance in the future is materially more or less than that upon which the plan is based. In other words, our plans for plant extension are considered broadly from all angles, and advantage is taken of the knowledge and experience which has been gained in the execution of similar plans in the past.

Effect of Street Railway Mercury Arc Rectifiers
On Communication Circuits

BY CHARLES J. DALY[1]
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Synopsis.—This paper describes the effects experienced on the telephone circuits from the two mercury arc rectifier substations recently installed in Bridgeport, Conn., and shows in table form the relative magnitude of the interfering effects between rotating equipment and mercury arc rectifiers as a means of energizing the street railway system. The method and the type of apparatus used to reduce the effects experienced from the rectifiers are also described.

* * * * *

THE application of the mercury arc rectifier for supplying power to street railway systems is now attracting a great deal of attention. In considering such an installation the question naturally arises as to its effect on communication circuits. In December 1927 all the current for the operation of the street railway system serving the territory in and around Bridgeport, Conn., was obtained for the first time from two mercury arc rectifier substations. A comparison of the relative interfering effects on the telephone circuits between this method and the previous method used for energizing this railway system was obtained and is described in this paper.

Both substations were not placed in operation at the same time, there being an interval of about four months between the installation of the larger station at Bridgeport and that of the smaller at Stratford. During this interval the larger rectifier station was operating in parallel with the rotating equipment of the old generating station for a short period of time only. Measurements of the interfering effect of the noise experienced on the various types of local telephone circuits were made just prior to the placing in service of the first rectifier station and immediately after each substation was connected on the line, as well as after temporary remedial measures were applied. The measurements obtained under these various conditions of energizing the railway system are shown in the accompanying tables.

Type of Telephone Plant

The Bridgeport exchange is a multi-office area served by three sub-offices, two of which are in the same building located in the business center of the city within one-quarter of a mile of the larger rectifier substation. The third sub-office is located in Stratford, approximately four miles from the Bridgeport central office building and within a quarter of a mile of the smaller rectifier substation. The interoffice trunk circuits connecting the Stratford telephone office with the Bridgeport main telephone offices are in underground lead-covered paper-insulated cables and with the exception of about one-half mile are parallel to and in the same streets with the railway system. See Fig. 1.

All subscriber telephone circuits on the same streets with the railway circuits are in lead-covered cables or twisted pair wire. The greater portion of the cable plant is in underground construction, although there are several relatively long runs where the cables are on poles jointly occupied with street railway circuits, and in a few instances on the same poles with both positive and negative railway feeders. There are no open-wire telephone circuits on the same streets with the street railway circuits.

The types of telephone service provided include

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standard individual line service on which metallic ringing is used, standard two-party selective and four-party semi-selective service, and private-branch-exchange service. In the selective service both the two-party and the four-party semi-selective types are provided.

It might be well to describe in some detail the signaling circuit used with the selective type of service. Fig. 2 shows the schematic wiring for a two-party selective circuit. It can be seen that each side of the telephone circuit is connected through a condenser, usually of 1 μ f. capacity, and then a ringer to ground. The ringer has a d-c. resistance of at least 1000 ohms and an impedance at 800 cycles of over 30,000 ohms.

Fig. 1

This connection to ground is used only for ringing purposes and not for transmitting the voice frequencies, as may be judged from the impedance in the ringing circuit to ground. With this arrangement the bell at one station can be rung independently of the one on the other side of the circuit.

The four-party semi-selective service is similar to the two-party service described above except that two stations are connected to each side of the circuit. With this arrangement, however, both bells on the same side of the line are rung when the ringing current is imposed on that particular side of the circuit. In the case of the individual-line service, signaling is obtained on an all-metallic basis by bridging the bell circuit across the telephone line.

Street Railway System

The street railway system consists for the most part of a double-track system with the rails and earth, supplemented along some of the routes with negative feeders, as the return circuit. Fig. 1 shows the railway system within the Bridgeport and Stratford city limits and the relative locations of the two rectifier substations. An interurban line extending to New Haven is furnished power from the Stratford substation for approximately half the distance or about seven miles. Another interurban line runs to Norwalk and is furnished power from the Bridgeport rectifier station for only about eight miles of its entire distance.

At the Bridgeport station there are five six-phase rectifiers which are energized from an 13,900-volt, three-phase, 60-cycle power line and deliver 600 volts direct current to the street railway system. Each rectifier is rated for 2000 amperes. Two similar type rectifiers are in the Stratford substation operating under the same conditions and in parallel with the Bridgeport station.

At the time of the writing of this paper a temporary filter had been installed in the street railway circuit in the Stratford rectifier station, but none had been installed at the Bridgeport rectifier station, although permanent filters were in the process of manufacture for both stations.

Method of Making Measurements

In order to determine the interfering effect experienced by the telephone subscriber under normal operating conditions, all measurements were made from the receiver terminals of the telephone instrument with the circuit connected through the switchboard to another telephone set located in the central office building. Measurements were obtained for various conditions that would be found in the practical operation of the telephone system. Such a condition, for example, is where two stations, due to the cancellation of the service or to the moving of the subscribers, have to be disconnected from a standard four-party semi-selective circuit leaving two stations connected to the same side of the circuit. This gives the maximum

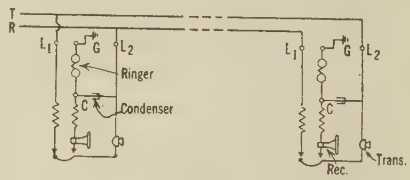

Fig. 2

unbalance produced in this type of apparatus under the various operating conditions.

Results of Measurements

Prior to the cutting into service of the Bridgeport rectifier station measurements of the noise on telephone circuits under various conditions were made at some 140 locations in Bridgeport and 50 locations in Stratford. After the installation of the rectifiers, measurements were made only at representative locations.

In Table I is shown the magnitude of noise obtained before and after the Bridgeport rectifier was cut into service in parallel with the rotating machinery in the old generating station. These measurements are

representative of the general noise situation on the local telephone circuits.

TABLE I
NOISE UNITS

Location Bridgeport	R-(T & R)		R-(T)		R-bridged		2-R (T)	
	1	2	1	2	1	2	1	2
A	20	50	35	75	20	50	35	100
B	10	20	20	35	0	10	20	50
C	20	35	20	50	20	35	35	150
D	35	100	50	125	35	75	75	250
E	20	50	20	75	20	35	35	100
F	20	50	35	75	20	50	50	150
Ave.	20	50	30	70	20	40	40	135
Stratford	1	2	1	2	1	2	1	2
A	20	35	75	100	20	35	75	200
B	20	35	35	50	20	20	35	100
C	20	20	35	35	20	20	35	35
Ave.	20	30	50	60	20	25	50	110

R-(T & R) = Ringer and condenser connected from each side of circuit to ground.
R-(T) = Ringer and condenser connected from one side of circuit to ground.
R-Bridged = Ringer bridged across circuit, no ground connection.
2-R (T) = 2 Ringers with their associated condensers connected from one side of circuit to ground.
(1) = Before rectifier was cut in.
(2) = After rectifier was cut in.

The measurements on the private-branch-exchange trunk circuits also showed an increase in the order of 125 per cent, but with the exception of three cases this increase was not sufficient to impair the telephone service seriously. In these three cases it was found practicable to take care of the noise by rearrangements in the telephone plant.

On the day the Bridgeport rectifier was cut into service, complaints were received from a number of telephone subscribers on account of the noise. The private-branch-exchange subscribers were the first to report the interference which in most cases was due to the large increase in the noise obtaining before the central office operator answered. This noise was greatly reduced, however, after the connection was completed. In order to reduce the noise level on some of the other circuits it was necessary to clear up some slight unbalances in the telephone plant which would not have had an appreciable effect with the rotating generating equipment furnishing the power.

There were no appreciable effects noted on the Bridgeport-Stratford interoffice trunk circuits.

When the Stratford rectifier station was cut into service there was no appreciable effect noticed on the telephone circuits in Bridgeport except for a small area near the exchange boundary along Stratford Avenue, but in Stratford, especially along Stratford Avenue between the two rectifier stations as shown in the shaded area on Fig. 1, the noise effects were greatly increased and the reactions from the telephone subscribers more serious. The Bridgeport-Stratford interoffice trunk circuits, however, showed no appreciable effects.

After this installation three times as many complaints were received from telephone subscribers as were received when the Bridgeport station was installed. Most of these complaints were from party-line subscribers.

Table II gives a general idea of the noise conditions before and after the Stratford rectifier was installed as well as the results obtained after installing a filter in the railway circuit.

TABLE II

Location Stratford	R-(T & R)			R-(T)			R-Bridged			2-R (T)		
	1	2	3	1	2	3	1	2	3	1	2	3
A	20	325	150	75	500	300	20	300	125	75	800	450
B	20	100	65	35	200	85	20	100	65	35	275	125
C	20	35	35	35	75	35	20	35	35	20	110	50
D	20	100	75	35	200	100	20	85	75	35	350	200
Ave.	20	140	80	45	245	130	20	130	75	40	385	205

(1) Power from old generating station.
(2) Mercury arc rectifiers at Bridgeport and Stratford.
(3) Same as (2) but with rectifier and filter at Stratford.

Wave Analysis

A wave analysis of the noise experienced showed 360,- 720,- and 1080-cycle components with the 360 cycle the most prominent. This latter is the fundamental frequency, in this instance, of the ripple in the rectified d-c. voltage wave and is equal to the product of the fundamental frequency of the supply line (60 cycles) and the number of secondary phases of the rectifier (6 phases).

The amount of these harmonic currents flowing over the railway distribution system is a function of the harmonic e. m. f. generated and the load characteristic of the system. Under these conditions, the most practicable means of limiting the flow of these disturbing harmonics on the railway system, and by so doing limiting their interfering effect on the telephone circuits, was to install a filter on the load side of the rectifier. This means of reducing the disturbing harmonics has been used to advantage in other places where the railway current is obtained from mercury arc rectifiers.

Filter Equipment

The first filter equipment installed in the Stratford substation was only temporary, but similar electrically to the proposed permanent equipment which was in the process of manufacture for both substations.

The equipment consists of a 0.7 millihenry series reactor inserted in the negative return circuit at the station. This reactor acts as a choke to the harmonic currents and of course must be able to carry the entire load current furnished by the station. There are also three resonant shunts connected between the positive and negative sides of the railway circuit on the load side of the reactor in order to by-pass harmonic current at 360, 720, and 1080 cycles, thereby reducing the voltages applied to the line at these frequencies. Each of these resonant shunts has a 2 millihenry air-core coil in series with a bank of condensers. Tuning is accomplished at each frequency by varying the capacity

until the harmonic line voltage is a minimum. The capacities obtained for resonance were 105, 28, and 12 μf., respectively. The condenser banks are built up of 1 μf. units made to withstand 600 volts direct current indefinitely. See Fig. 3.

Results of Filter Installation

The effect of the filter on the noise levels in the telephone circuits in the Stratford exchange area was quite appreciable and the complaints from the telephone subscribers dropped to only a few cases in the

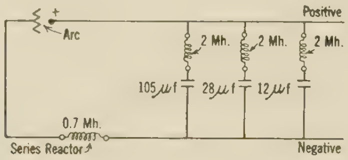

Fig. 3

shaded area along Stratford Avenue. The noise measurements obtained are shown in column 3 of Table II. Measurements made with the temporary filter installed in Stratford indicated that a large part of the remaining noise, given under column 3, resulted from the unfiltered rectifier at Bridgeport. It is expected that when a filter is also installed in the Bridgeport substation a further reduction in the noise levels in this particular area will be obtained.

Conclusion

The magnitude of the interference from a given source, in this case the mercury arc rectifier, depends on the distribution and type of plant of both the street railway system and the telephone system. As shown in Tables I and II, this is clearly indicated by the more serious reactions obtained on the same types of telephone circuits in the Stratford area than in the Bridgeport area. The type of rectifier installed in both areas is the same, but in the Stratford area a larger percentage of the telephone plant is in aerial cable construction with more joint pole line construction with the railway circuits than in the Bridgeport area, where the degree of exposure between aerial telephone and street railway circuits is relatively small.

From the experience obtained with the installation of the six-phase mercury arc rectifiers for the street railway system in Bridgeport and adjacent territory it can be definitely stated that in general a street railway system energized by mercury arc rectifiers possessing no means of limiting the harmonic components has a greater inductive influence on neighboring communication circuits than when energized by rotating equipment. General experience has shown, however, that by means of properly designed filtering apparatus installed on the d-c. load side of the rectifier, the inductive influence of such a rectifier may be reduced to a level comparable with that of rotating equipment of good wave shape.

ELECTRICITY AND THE HUMAN BODY

If electricity can have performed so many remarkable services in lightening labor, if it can have raised the standard of living throughout the world, must we continue to say that it is impotent in repairing bodies and in keeping them in repair?

Not for long, certainly. Electrotherapeutics has passed the stage of charlatanism and magic and has settled down to sober and honest progress. The alluring but entirely fictitious powers of "electronic reactions" and all their breed have been exploded and electricity has at last taken an active hand. Chemistry, once the only reliance of medicine, has a new and powerful ally whose purpose, like that of its colleague, is sound investigation and reproducible results. Ultra-violet light from electrical sources, far more powerful than sunlight and yet more controllable, has already gained a substantial reputation in medicine. It is conceded to be a cure for rickets, a powerful assistant in the treatment of tuberculosis and a bactericidal agent of great value in surface infections. It is also receiving much attention as an active force in the production of the still mysterious vitamins in foods. X-rays, thanks to the intensive developmental work done by science, are now under effectual control and with each new advance in the art of their production they are finding new applications in the war against disease and disability. At first their value lay principally in their great assistance in medical diagnosis, but they are now the basis of a complete new therapy, having well established uses in the treatment of certain kinds of cancer and kindred ailments.

These two—ultra-violet light and X-rays—are already firmly established. But there are other electrical phenomena that may soon serve the doctor in his fight for men's bodies. High-frequency currents, whose curative power has been in dispute for years, are now suggested in medical circles as a possible means of aiding natural convalescence by producing artificial fevers. And recently has come the announcement of the cathode-ray tube, which can produce many hundred times more radiation than is given off by all the radium in the world and, unlike that rare metal, is under perfect control. Neither doctor nor scientist can say at present what the cathode ray may do for medicine, but it is quite possible that great benefits may come from it.

These are a few of the contributions and the promises which electricity, turning from the remodeling of industry, has made to man himself. Research in its unending perseverance, supported by an open public mind, may turn these promises to realities, and it may reasonably be hoped that pain and suffering will steadily decrease throughout the world.—*Electrical World.*

Abridgment of

Interconnection of Power and Railroad Traction Systems by Means of Frequency Changers

BY LUDWIG ENCKE[1]

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Synopsis.—Several types of variable ratio frequency changers are discussed and installations of such apparatus on the electrified section of the New York, New Haven & Hartford Railroad are described in some detail.

These types of frequency changers permit a flexible tie between interconnected systems, and accurate and automatic control of load regardless of variations in voltage or frequency in either system.

Any desired constant load transfer in either direction may be obtained through the apparatus by manually setting a load-regulating relay. Provision is made also for operating the sets as synchronous condensers, to improve power factor.

The functioning of regulating machines and auxiliary equipment to obtain the desired results is explained, together with a description of switching equipment installed in connection with the main units.

A NUMBER of methods may be employed for connecting two power systems of different frequencies for interchange of power.

A rigid tie by means of a synchronous motor-generator is common at the present time and is, in many respects, the simplest form of connection. This rigid connection, however, does not permit any regulation of the transferred load on the set itself; furthermore, synchronizing is somewhat difficult.

A flexible connection is desirable and even necessary in some instances, and obviously possesses fundamental advantages over any method of rigid tie, in that it permits not only tying together two power systems of different frequencies for interchange of power, but a close control of load as well. This may be of especial value in the supply of power for the operation of an electrified steam railroad extending over a large territory from two or more central station generating plants located at widely separated points. In case of a single-phase electrified railroad it may be desirable to change the 60-cycle power available in most commercial power systems into 25-cycle power, necessary for traction purposes, at the same time operating in parallel with existing power plants owned by the railroad. By means of flexible connections, any desired load distribution amoung various substations may thus be readily obtained regardless of variations of frequency in any of the interconnected systems, all variations being absorbed in the machines themselves. Such flexible frequency-changer motor-generator sets are known as variable-ratio machines.

At present, the single-phase 25-cycle system of the New York, New Haven & Hartford Railroad is fed mainly from the railroad's own power plant at Cos Cob, Connecticut. Power is supplied also from the Sherman Creek plant of the United Electric Light and Power Company at New York. With increasing loads it has been found desirable to provide energy sources on the eastern end of the electric zone, and connections have been made by means of the variable-ratio motor-generator type at New Haven with the 25-cycle system of the Connecticut Company, and at Devon, Connecticut, with the 60-cycle power system of the Connecticut Light and Power Company. In connection with the recent electrification of the New York Connecting Railroad and the Bay Ridge line of the Long Island Railroad, another frequency-changer set, a duplicate of the New Haven set, has been installed in the substation of the Long Island Railroad at East New York.

The power flow through the sets is controlled by adjusting the speed of the induction motor. This type of apparatus consists fundamentally of an induction motor and a synchronous generator (though the power flow may be in either direction) with appropriate auxiliary facilities. The common method of speed regulation of an induction motor by inserting resistances in its rotor circuit has the disadvantage of being uneconomical. Furthermore, only regulation below synchronism can be obtained. In the variable-ratio frequency-changer sets the slip energy of the induction motor is transferred to an additional machine, the so-called regulating machine, where it is transformed into either mechanical or electrical energy, depending on the type of machine employed, and thus utilized. By changing the excitation of the regulating machine, a variable voltage is produced which, reacting (bucking or boosting) upon the slip voltage, brings about the speed regulation of the induction motor.

Fig. 4 shows the wiring diagram of the frequency-changer sets installed in the New Haven and East New York substations. They consist of a main set and an auxiliary set. The main set is made up of a three-phase 25-cycle 11,000-volt synchronous generator with d-c. exciter, a three-phase 25-cycle 11,000-volt induction motor, the speed of which is determined by the synchronous generator and the regulating machine which regulates the power flow of the set. The machines of the auxiliary set are, first, a synchronous motor used for the drive; second, a so-called a-c. exciter machine; and,

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third, a d-c. exciter furnishing the excitation for the other two machines. The induction motor, the synchronous generator, and the d-c. exciter of the main set are of standard design. The regulating machine is a rotor-excited, neutralized, a-c. commutator machine, the three-phase wound rotor having slip-rings and a commutator as in a rotary converter. Since the slip-rings carry alternating excitation current only, they are relatively small and the commutator segments are narrow, a feature of every a-c. commutator. The stator has a compensating winding which neutralizes the rotor field generated by the load current in the rotor, so that the machine can transform electrical energy to mechanical energy. The design of this machine is limited by the maximum permissible values of peripheral commutator speeds, the voltage between commutator bars and current densities. A satisfactory

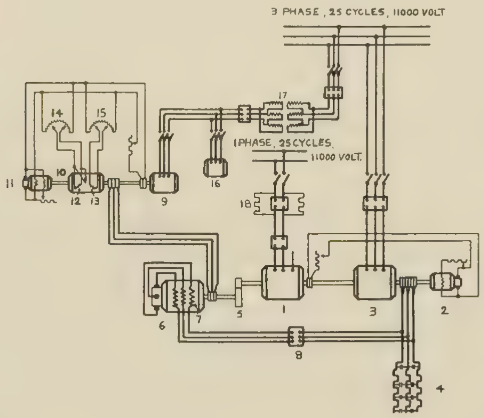

Fig. 4—Diagram of Main Connections for the Frequency Changer Sets Installed at New Haven and East New York

1. synchronous machine
2. d-c. exciter
3. main induction motor
4. secondary starting resistances
5. reduction gear
6. polyphase regulating machine
7. neutralizing windings
8. tie breaker
9. synchronous driving motor
10. a-c. exciter machine
11. d-c. exciter
12. load field windings
13. power-factor field winding
14. load field rheostat
15. power-factor rheostat
16. blower motor
17. auxiliary set transformer
18. current limiting resistances

design thus requires that the kv-a. output per pole be somewhat limited, and in order to obtain the required rating, it was desirable to build the machine at a slower speed than the main unit. The regulating machine, therefore, is connected to the main shaft through a reduction gear with a ratio of two to one, and thus rotates at half the speed of the main set.

In order to understand the operation of this machine it may be assumed that the connections from its commutator brushes to the slip-rings of the main induction motor are cut off and the slip-rings are connected directly to the line.

At standstill a field will rotate with $n_1 = \dfrac{60\, v_1}{p}$ rev. per min. with regard to the stator and rotor, where

v_1 = frequency of the line

$2\,p$ = number of poles of the machine.

In rotating the rotor with n revolutions opposite to the direction of the field, the resultant speed relative to the space will be:

$$n_1 - n$$

The voltage of the frequency $v_2 = \dfrac{p\,(n_1 - n)}{60} = s_2\, v_1$

is obtained at the brushes of the commutator, where

$$s_2 = \text{slip}$$

The effective values of the voltages at the slip-rings and at the commutator brushes are practically equal. When $n_1 = n$, direct current appears at the brushes of the commutator. Therefore, if the regulating machine is given the same ratio of revolutions and number of poles as has the main induction motor, and the slip-rings are fed with line frequency, the slip frequency $v_2 = s_2\, v_1$ will always appear at the commutator brushes. Thus the commutator brushes of the regulating machine and the slip-rings of the main induction motor may be connected. As the voltages at the slip-rings and at the commutator brushes of the regulating machine are about the same, the latter, and thus the speed of the main set, can be easily controlled by changing the voltage applied to the slip-rings of the regulating machine. It is a function of the auxiliary set to furnish to the slip-rings of the regulating machine this variable voltage at line frequency. The continuous delivery of line frequency is insured, as the auxiliary set is a straight synchronous motor-generator connected to the same line as the induction motor. The driving synchronous motor as well as the d-c. exciter are of standard design.

The a-c. exciter machine resembles an induction motor. Its field consists of three windings with a phase-angle difference of 120 deg., two of which are connected in multiple. These windings, independent of each other, excited by direct current, set up two fields which create a resultant field. The field of the two windings connected in multiple is the load field controlled by the load rheostat, whereas the field of the single winding is the power-factor field, 90 deg. out of phase with the load field, controlled by the power-factor rheostat. The load adjustment of the main set is obtained by changing the voltage generated in the a-c. exciter which is accomplished by varying the load rheostat, while the power factor of the main induction motor is adjusted by changing the power-factor rheostat, which is of a potentiometer type. For running above synchronism the voltage of the regulating machine must be reversed; therefore the load rheostat is a reversing rheostat. Both the load and the power-factor rheostats are motor-driven. (Figs. 5, 6, 7.)

As outlined above, this variable-ratio frequency-changer set represents an interconnection between two 25-cycle systems. If, however, the induction motor is a 60-cycle machine the excitation for regulation would also be 60-cycle. The inherent frequency is then higher, a condition which is not desirable with rotor excitation on so large a set. Some other arrangement is thus

necessary. This condition may be cared for by replacing the rotor-excited regulating machine by a stator-excited type.

A slightly different means of regulation, known as the Scherbius system, is employed in the installation at Devon. The same system may be applied to connections between two 25-cycle systems or between a 60-cycle and a 25-cycle system.

Fig. 11 shows the wiring diagram of the Devon set.

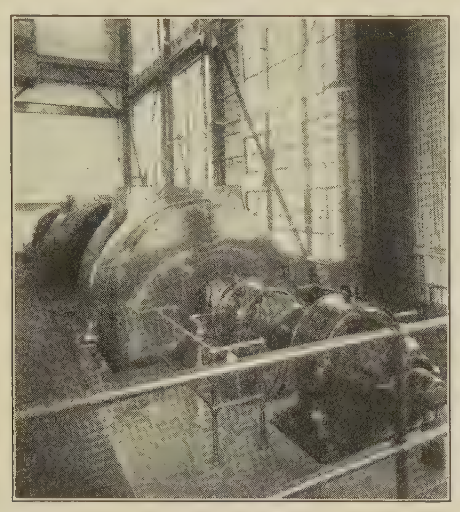

Fig. 5—Variable Ratio Frequency-Changer Set at Station "A," New Haven

All machines (the synchronous generator, the d-c. exciter, the induction motor, the regulating machine, and the so-called ohmic drop exciter) are installed on one shaft. The Scherbius machine, resembling a d-c.

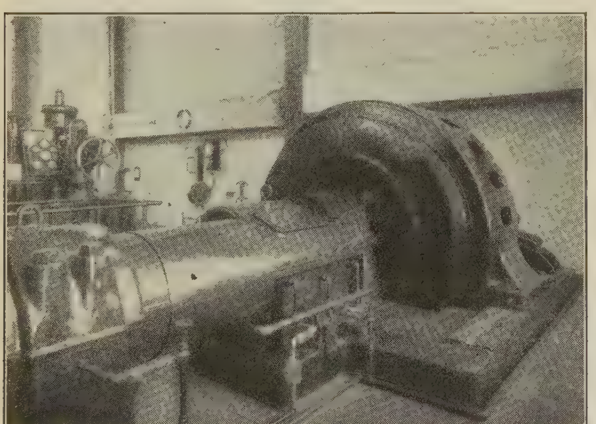

Fig. 6—Regulating Machine and Reduction Gear of the Main Machine Set at Station "A," New Haven

machine, is typical for these regulating sets. Like a d-c. machine, it has main poles and interpoles. The excitation, however, is alternating current instead of direct current. As the frequency of the excitation voltage determines the frequency at the commutator brushes which are connected to the slip-rings of the main induction motor, the regulating machine must be excited with slip frequency. Furthermore, the voltage existing at the commutator brushes, and thus the speed of the regulating set, is controlled by varying the excitation voltage.

This excitation voltage is furnished from the line through a special auxiliary machine known as an ohmic drop exciter or frequency-changing exciter which works as a frequency converter. Its operation resembles that of the regulating machine previously described. The rotor is analogous to the rotor of a rotary converter in that it is three-phase wound and has slip-rings as well as a commutator. The stator has no field winding and is merely a laminated steel ring to provide a flux path. The slip-rings are connected through a transformer to the line. Since it is mechanically coupled to the main induction motor and has the same number of poles, a voltage of slip frequency exists at its commutator brushes, which is employed for the excitation of the regulating machine. The commutator carries two sets of brushes which are moved by a brush-shifting device, and the regulation of the excitation voltage is accomplished by shifting these brushes. That is, by moving the brush-shifting device in one direction or the other,

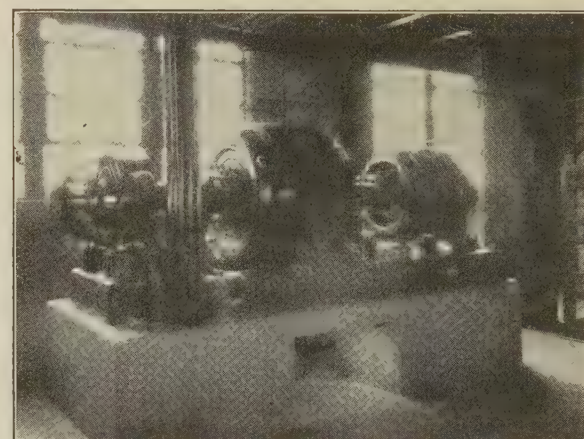

Fig. 7—Auxiliary Set at Station "A," New Haven

more or fewer commutator bars are included between the brushes and the excitation voltage applied to the regulating machine is thus raised or lowered. The brush-shifting device provides for operation at under-synchronous as well as above-synchronous speed by reversing the excitation voltage. Two contactors, A and B, are provided in the connections between the ohmic drop exciter and the regulating machine. During under-synchronous operation, as well as at synchronous speed, contactor B is closed, connecting the ohmic drop exciter to the Scherbius machine through its interpoles, whereas above synchronous speed, the contactor A is closed, connecting the ohmic drop exciter directly to the Scherbius machine.

As in the regulating sets of other types, these sets also are equipped with apparatus to correct the power factor of the main induction motor. As shown in the wiring diagram, Fig. 11, the so-called power-factor rheostat is connected in series with the load-control field windings of the regulating machine. The degree of lag of the exciting current behind the voltage can be

varied in changing the resistance of these windings by means of the rheostat. In addition, the regulating machine is equipped with separate power-factor control windings, which are used when no excitation is supplied to the load-control field circuit, the first method described for power-factor correction being under these

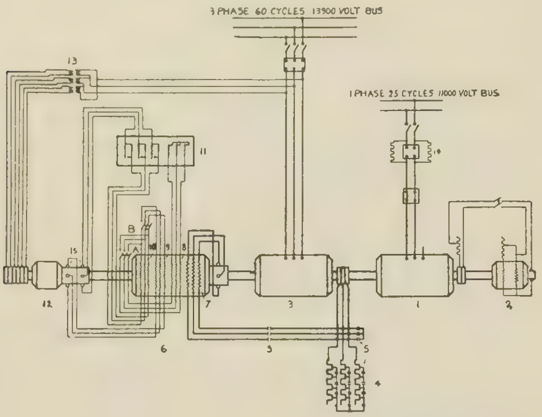

Fig. 11—Diagram of Main Connections for the Frequency-Changer Sets Installed at Devon

1. synchronous machine
2. d-c. exciter
3. main induction motor
4. secondary starting resistances
5. contactors
6. regulating (Scherbius) machine
7. neutralizing windings
8. power-factor control field windings
9. interpole field windings
10. load control field windings
11. power-factor rheostat
12. ohmic drop exciter
13. ohmic drop exciter transformer
14. current limiting resistances. A & B contactors
15. movable brushes

conditions ineffective. These separate power-factor control windings are connected from one set of brushes through a second section of the power-factor rheostat to a star point. The voltage supplied to the power-factor control windings is constant and about in quadrature to that of the load-control field. As the excitation in the load-control windings is increased, the effect of the power-factor control windings is reduced. Both brush-shifting device and power-factor rheostat are motor-operated. (Figs. 11 and 12.)

All of the regulating sets are started from the induction motor side of the main set by inserting resistances in its secondary. After the induction motor has reached its full speed, its secondary slip-rings are connected to the commutator of the regulating machine; thus, speed and power-factor control of the main induction motor may be applied. Full automatic starting of the sets has been provided in all cases.

The synchronous generators furnishing the single-phase railroad power are built as three-phase machines. All sets are designed for a frequency variation of $\pm$ 3 per cent in each system. The stators are all spring-mounted in order to reduce vibration due to the single-phase load. These springs are installed on both sides of the stators which are thus entirely supported by them. Leaf springs are used at New Haven and East New York, while at Devon helical springs are employed.

All installations are equipped with automatic load regulators which, when adjusted for any given kw. value, provide that during all variations of frequency in the interconnected systems within the allowed limits the transferred kw. load shall remain constant. Two different types of load regulators are used; in the New Haven and East New York substations a rheostatic type is installed, while those in the Devon substation are of a polyphase induction type.

Typical for every single-phase railroad load are the heavy and sudden swings of the load in kw. as well as the reactive kv-a. load. Nevertheless, in putting the machine under the control of the automatic load regulator, a given kw. load representing a base can be accurately maintained, while the swings are taken up by another source of supply. Any desired load within the capacity of the machine can thus be adjusted.

Figs. 15 and 20 show such a kw. curve, and it is of interest to note how the load was kept constant within comparatively narrow limits, in spite of the widely varying system load.

The sets at New Haven and East New York have been arranged for power flow in both directions. Fig. 16 shows such an operation.

When not operated as a tie, the generators can be used as synchronous condensers on the single-phase railroad line, while the induction motor, with the auxiliary machines, are disconnected from their busses. The synchronous condensers are operated under the control of the voltage regulators, thus maintaining so far as possible a constant line voltage up to the kv-a.

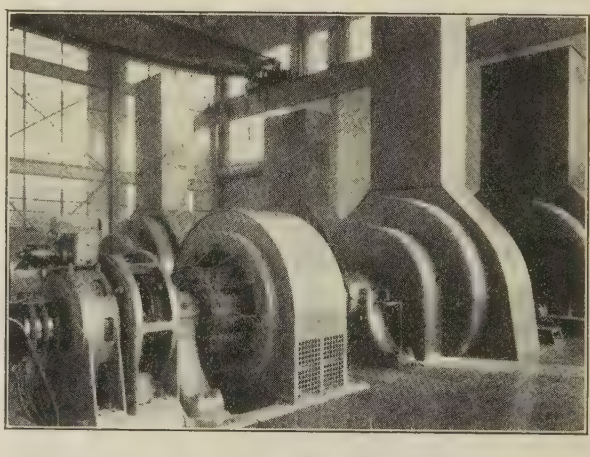

Fig. 12—Variable Ratio Frequency-Changer Sets in the Substation at Devon

capacity of the machine. In order to protect the unit against overload under these circumstances a current-limiting device is installed in connection with the voltage regulators; when the field current reaches a safe limit, the reactive kv-a. on the machine is automatically limited and the line voltage allowed to drop.

One feature of interest common to the installations at New Haven and Devon is the protective arrangement to obtain selective operation on short circuits on the single-phase railroad system. Current-limiting resistances are installed on the single-phase ends of the machines, which are normally short-circuited by circuit breakers. In the event of a fault or ground on the railroad system, these resistances are automatically

inserted by opening the circuit breakers, after which the local sectionalizing circuit breakers on the line feeding the fault are allowed to trip. The resistances are automatically short-circuited after the faulty section is cut out, and normal operation is resumed. In case

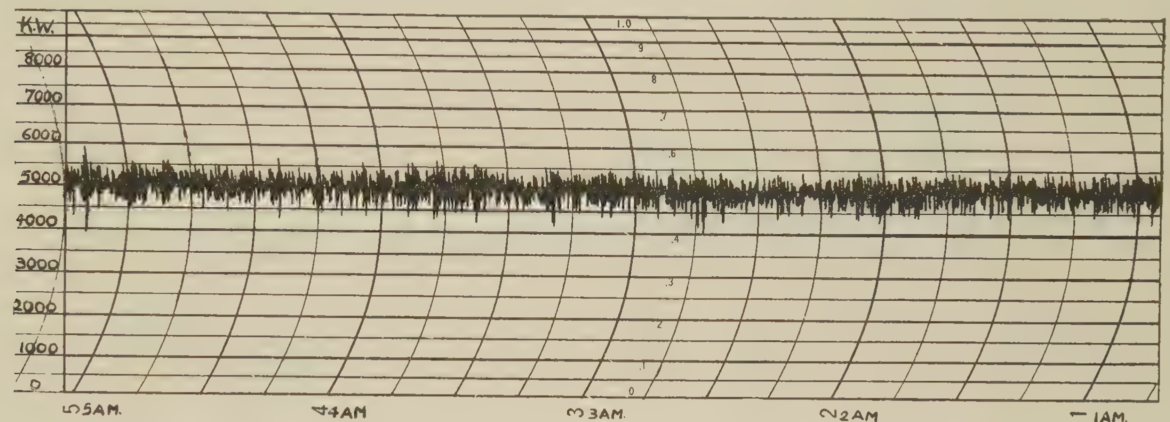

Fig. 15—Kw. Load on the Frequency-Changer Set at New Haven

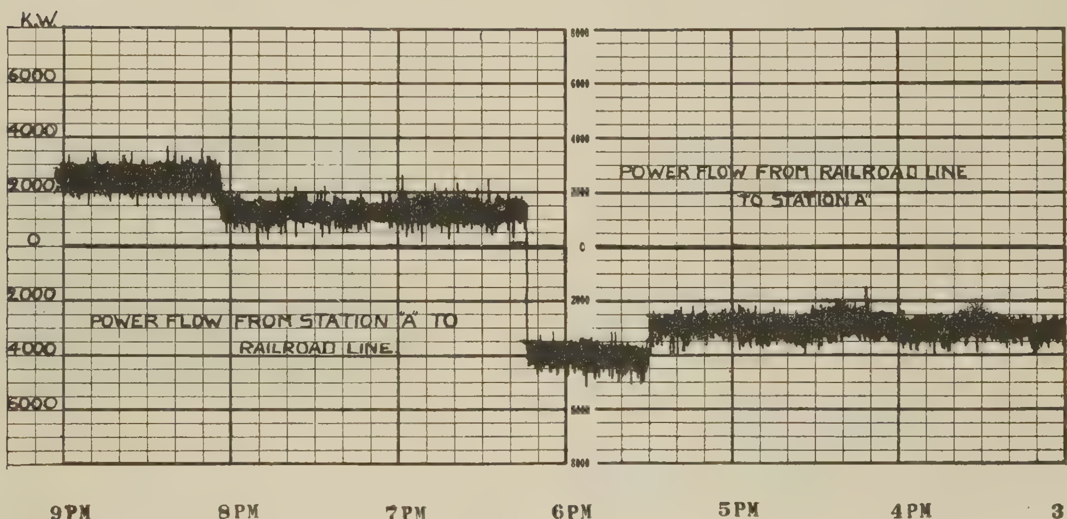

Fig. 16—Kw. Load Curve for Power Flow in Both Directions

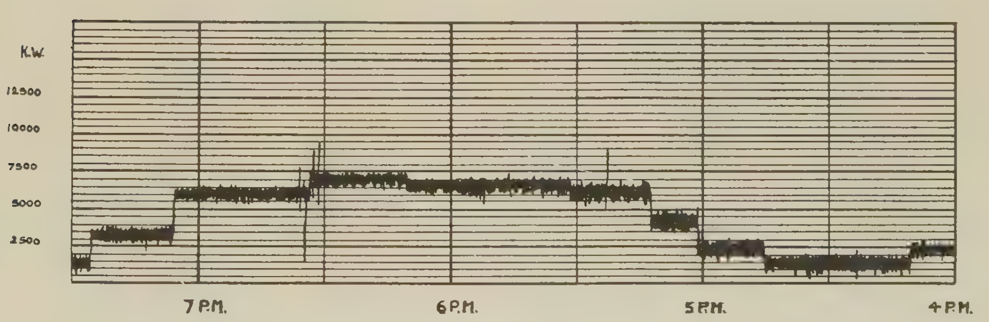

Fig. 20—Kw. Load on the Frequency-Changer Set at Devon

of the failure of the line breakers to clear the line, the whole substation is separated from the railroad line after a predetermined time by the opening of the main circuit breakers.

The installation at Devon and New Haven were made under the general direction of Sidney Withington, electrical engineer of the New York, New Haven & Hartford Railroad, H. F. Brown, assistant electrical engineer, and the writer. That at East New York was under the general direction of L. S. Wells, electrical superintendent of the Long Island Railroad. Messrs. Gibbs and Hill, New York, acted as consulting engineers for all the installations.

A High-Speed Graphic Voltmeter

for Recording Magnitude and Duration of System Disturbances

BY A. F. HAMDI[1] and H. D. BRALEY[1]

Member, A. I. E. E. Associate, A. I. E. E.

Synopsis.—This paper deals with a graphic voltmeter for recording the magnitude and duration of system disturbances. It also deals with operating experiences with this device, together with the importance of the data obtained.

Introduction

THE high-speed recording voltmeter described in this paper is one of a number of types now on the market which have been built in order to supply the needs for a type of instrument which would give an accurate record of system disturbances. It was felt that such instruments would be useful in determining actual magnitude and duration of disturbances and their relation to the operation of high-tension circuit breakers and relays on apparatus connected to the system.

The first part of this paper deals with the description of the electrical and mechanical details of this instrument, with particular reference to the requirements which were submitted to the manufacturers who developed the device. These requirements resulted from four years of operating experience with a similar type of instrument which accomplished the results desired. The second part of the paper deals with the interpretation of the records obtained and their value to the Engineering and Operating Departments in analyzing system disturbances.

Several years ago the Engineering Department and Test Department of the New York Edison Company investigated the methods available for obtaining records of voltage dips during disturbances on power systems, and as a result an instrument was developed which consists of a high-grade graphic voltmeter driving a chart at normal speed and an auxiliary circular chart driven at relatively high speed. To the pen arm of the graphic voltmeter is attached a long pointer in addition to the standard pen of the instrument. This long pointer reaches over to a circular smoked chart which revolves at the rate of 2.5 rev. per min. (24 sec. per revolution). This circular chart is driven by a d-c. motor operating from the station control battery so that its speed is not influenced by the changes in system voltage. With this device it is possible to obtain records of both magnitude and duration of all disturbances. Two of these instruments have been in successful operation for four years and have given quite satisfactory results. The main objection to this device is that the smoked chart has to be renewed after each disturbance. It was therefore desired to obtain an instrument which would eliminate the above difficulty by giving the high-speed record on the standard strip chart.

From the operating experience obtained with the above instruments, certain specifications were drawn which were placed in the hands of instrument manufacturers and resulted in the development of the instrument described in this paper. With this device the high chart speed is 3600 times the normal chart speed and the change-over is accomplished in 0.05 sec. or less (1 to 3 cycles for 60-cycle systems).

The following characteristics were required:

1. A graphic voltmeter responsive to all voltage fluctuations, but well damped so as to be free from over- or under-shooting even for 100 per cent voltage fluctuations (suddenly energized to 115 volts or 115 volts suddenly interrupted).

2. Instrument to take 1.0 sec. or less to reach 115 volts when suddenly energized.

3. High-speed timing accuracy to be within 0.1 sec.

4. Chart acceleration time 3 cycles or less on 60-cycle systems (0.05 sec.).

5. Low-voltage relay capable of being set to function on a voltage dip of 5 per cent of normal or less.

The manufacturers were left entirely free to work out all details.

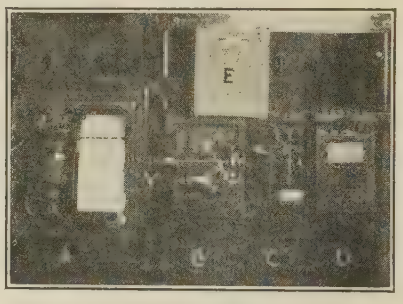

Fig. 1—General View of a Graphic System—Disturbance Recorder

Description

The device described in this paper is illustrated in Fig. 1. It consists primarily of a standard type of graphic voltmeter A, a chart accelerator B, a contact-making voltmeter C, and the necessary resistors D and E. The wiring diagram of this device, together with

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the schematic layout of the component parts, are shown in Fig. 2.

All the component parts of the above device are designed to operate at 115 volts, 60 cycles, with the exception of the magnetic clutch, which operates at 120 volts d-c. The contact-making voltmeter can be set to function at all dips in voltage amounting to two per cent of normal, or more. Actually, however, it is set to function at 5 per cent dips.

Under normal operating conditions the strip chart of

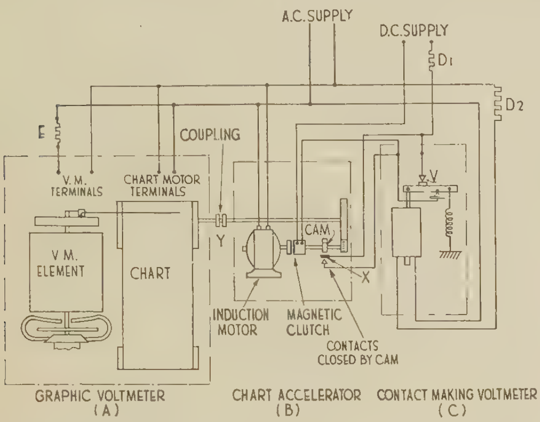

Fig. 2—Schematic Layout and Wiring Diagram

the graphic voltmeter A runs at the normal speed of 3 in. per hr.; the salient-pole induction motor of the accelerator B runs continuously at synchronous speed; and the contact-making voltmeter C being energized at full voltage holds open its contact V. As soon as a dip in voltage occurs, amounting to five per cent of normal or more, the contact-making voltmeter closes its contact and energizes the magnetic clutch of the chart accelerator B. When the clutch engages, the chart accelerator motor runs the strip chart of the graphic

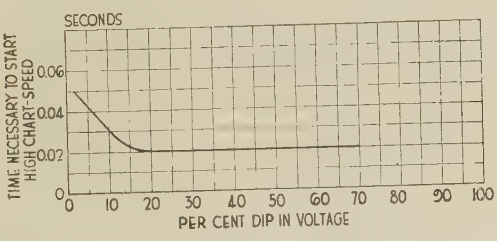

Fig. 3—Starting Time of High Chart Speed

voltmeter at the high speed of 3 in. per sec. The high speed continues even after the disturbance is over, for a length of chart equivalent to 24 hr., or 24 sec. in actual time. At the end of this time, a cam, which is operated by a worm gear, located on the magnetic clutch shaft, opens the circuit of the magnetic clutch at point X (see Figs. 1 and 2). If the voltage is back to normal, the slow chart speed is resumed as the contact-making voltmeter contact V would then be open. In case the voltage is still below normal, the contact-making voltmeter will have its contact V closed and the cam will keep the device running at high speed for an additional period of 24 sec. Normally the cam holds the contact at X open.

The time necessary for the accelerator to speed up the chart has been carefully investigated and was found to be dependent upon the magnitude of the voltage dips which affect the speed of operation of the contact-making voltmeter. For all dips amounting to more than 20 per cent of normal the device requires 0.02 sec., (1.2 cycles) to change over to the high speed. With dips less than 20 per cent, the change-over time may be as high as 0.05 sec. (3 cycles). The variation in this time is shown in Fig. 3.

The timing accuracy of the high-speed chart is correct within 0.1 sec. for the full length of the high speed run

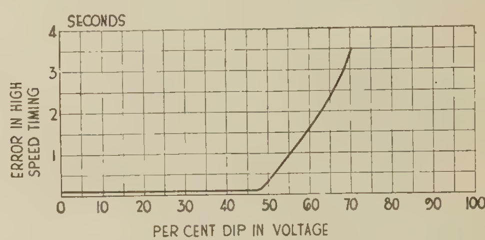

Fig. 4—Timing Error in 24 Sec. at High Chart Speed

(72 in. length of chart) providing the dip does not exceed 50 per cent of normal. For greater dips in voltage, the accelerator motor slips and the timing error becomes greater. The curve in Fig. 4 shows the timing error during 24 sec. for voltage dips up to 70 per cent. For voltage dips beyond 70 per cent the driving motor stops if the disturbance is sustained. However, the motor requires about 5.5 sec. to come to rest even if the voltage fails completely. Fig. 5 shows the record of a 100 per cent dip lasting for 1.08 sec., where the magnitude was correctly recorded. The time was in error by 0.2 sec. It should be noted, however, that for 100 per cent dips lasting for more than one sec. the magnitude can be

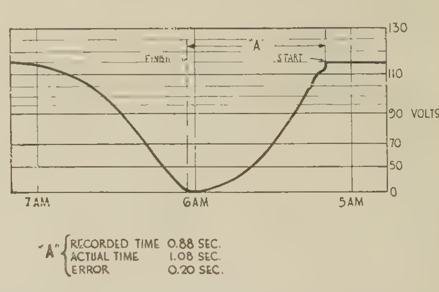

Fig. 5—Test Record of a Complete Voltage Failure

Voltage reestablished at the end of 1.08 sec.

obtained directly from the chart even though the duration is not correctly recorded.

To permit correct time resetting for slow speed after a disturbance, the high speed should last 24 sec., but actually it lasts only for about 23.96 sec. Therefore, there is a reset error in timing amounting to approximately 0.12 in. of chart length, which at slow speed means 2.5 min.

After the contact-making voltmeter operates to energize the magnetic clutch, 0.28 sec. is required for the cam to close the "hold-in" contact at X (see Fig. 2). Therefore, for disturbances having durations of less than 0.28 sec., the high speed lasts only as long as the disturbance, and the cam does not come into play. Fig. 6 shows such a short duration disturbance which was cleared in about 0.1 sec. However, if a number

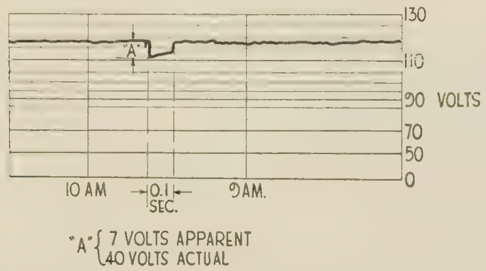

Fig. 6—Record of Momentary System Ground—Cause Unknown

of short disturbances occur in succession, the cam will close the contact at X and a length of chart equivalent to 24 hr. will be run off as soon as the several short duration disturbances add up to 0.28 sec.

In Fig. 7 is shown a set of calibration curves applying to this recorder. These curves have been prepared by

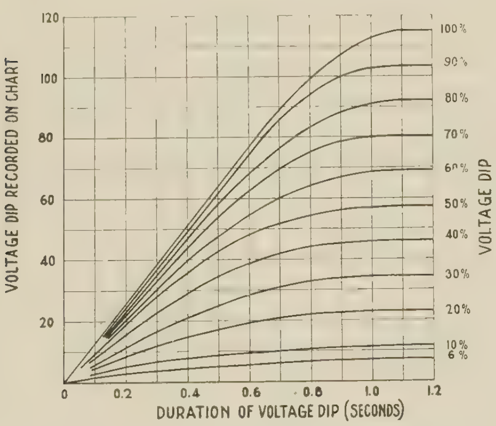

Fig. 7—Calibration Curves for Determining True Voltage Dip

subjecting the device to voltage dips of known magnitude and duration, and plotting voltage values obtained from the chart (ordinates) against time (abscissas). Normal voltage was 115 volts.

The following procedure would be used to obtain the magnitude of a disturbance of known duration. From the high-speed section of the chart, obtain the apparent maximum dip in voltage and the duration of the disturbance. Plot the point corresponding to these two observations on the calibration curves. The true per cent voltage dip can then be obtained by comparing the position of the point so plotted to the calibration curves. As an example, if the apparent voltage dip were 40 volts, and the duration of the disturbance were 0.40 sec., we find by reference to Fig. 7 that the point determined by these two values falls very close to the 60 per cent dip curve. Therefore, we conclude that the actual dip was approximately 60 per cent of normal or 70 volts.

In connection with these calibration curves it should be pointed out that it is quite essential to have a properly damped instrument. If the instrument overshoots to a considerable amount, the records will not be smooth curves as shown in Figs. 8, 9 and 10, but will be wavy curves. Reference to the calibration curves in Fig. 7 shows that in the case of the instrument

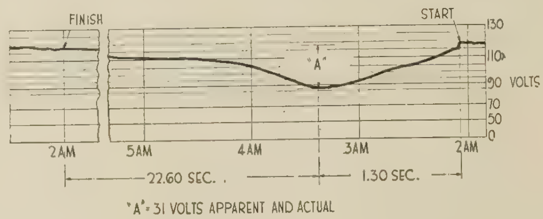

Fig. 8—Record of Short Circuit on 13,800-Volt Feeder

discussed, there is no overshooting and the instrument reaches full indication in about 1.1 sec. In other words, for disturbances lasting over 1.1 sec. there is no need for reference to the calibration curves, as the maximum dip recorded on the strip chart is the true dip.

Operating Experience

Since this instrument was placed in service, on a 60-cycle cable system, 15 records of voltage disturbances were obtained. Most of these voltage dips were 20

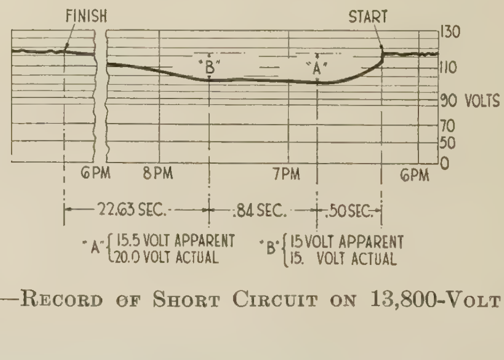

Fig. 9—Record of Short Circuit on 13,800-Volt Feeder

per cent or less of normal voltage and the trouble was cleared from the system automatically in 1.5 sec. or less. While practically all of these faults show the same characteristics there were a few cases of rather different nature which illustrate the adaptability of the instrument for this service. In the following figures the smooth voltage recovery sections have been cut off in order to shorten the length of the records. The broken lines show where chart sections have been cut off.

Fig. 8 is a typical record which is representative of the voltage disturbances resulting from faults on the system. This record shows a dip of 31 volts, or approximately 26 per cent, the disturbance being cleared by the opening of the circuit breakers after 1.3 sec. It may be noted that the duration of the disturbance is measured from the start to a point where the voltage begins to recover.

Fig. 9 illustrates a disturbance which lasted for 1.34 sec. before it was finally cleared. The first circuit breaker opened after 0.50 sec., while after an additional 0.84 sec. the second circuit breaker cleared the other end of the feeder. Since the first switch opened after but 0.5 sec. the instrument did not attain its maximum swing, the calibration curves showing the actual dip to be 20 volts instead of 15.5 as recorded. This curve also illustrates the manner in which it is often possible to obtain a check on relay operations, as two distinct circuit breaker operations are indicated.

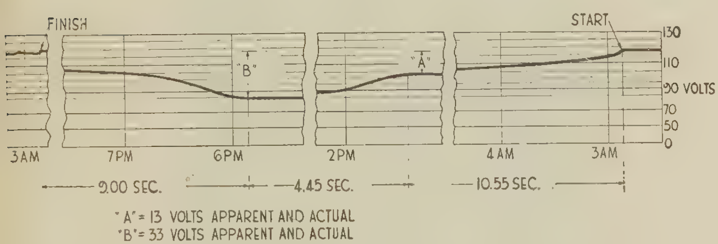

Fig. 10—Record of Ground and Short Circuit on 27,000-Volt Feeder

Fig. 10 is an unusual case in that the disturbance lasted for approximately 15 sec. before it was finally cleared. In this case a triplex cable became grounded at a considerable distance from the supply end and was not cleared immediately because the moderate ground current was insufficient to cause the overload relays to operate. The voltage dip due to the ground was approximately 11 per cent and lasted about 10.55 sec. Apparently the ground then developed into phase trouble causing a dip of about 28 per cent and was finally cleared after an additional 4.45 sec.

In each of the above cases the records show that a considerable length of time is required for the voltage to return to normal. Of this time, one sec. is due to time lag in the instrument if the dip is 100 per cent. If the dip is less than 100 per cent, the time lag of the instrument will be correspondingly reduced.

Fig. 6 illustrates a case in which a momentary ground occurred which apparently cleared itself in about 0.1 sec. The contact of the contact-making voltmeter opened before the cam could operate the hold-in contact to continue the high-speed operation.

While an instrument of this nature will not record instantaneous changes in voltage or current, it does afford a means of giving directly a fairly accurate picture of the disturbance even though it may last several minutes. All disturbances are recorded by this instrument even if they last more than 24 sec. because the instrument will operate continuously through successive periods of 24 sec. as long as the contact-making voltmeter contact is closed. An instrument designed to operate on current instead of voltage, for example, would give a record of surging between generating stations due to a condition of instability which might last for several minutes. Such an instrument may also be installed at grounding points to indicate the magnitude and duration of ground fault currents as a check on the effectiveness of the grounding itself and for checking relay operations.

The results obtained with the device described have been quite satisfactory from both the operating and the maintenance standpoints. The records obtained have given sufficiently accurate information in regard to the magnitude of voltage dips and their relation to operation of low-voltage relays. These records have an additional value in that they often afford a means of checking automatic circuit breaker operations and also give a fairly accurate indication of the effect of faults on the system in general.

SUBSTATIONS PASSING OUT

Load growth in the electrical industry keeps engineers and system planners keyed to a high pitch. In larger cities a density is found ranging from 3000 kw. to 300,000 kw. per sq. mi., and this density keeps on creeping upward. A ten-year perspective on load growth gives a new conception of a metropolitan system; it modifies present layouts and makes radical changes necessary.

The substation seems to be an expensive and hazardous incumbrance on the metropolitan system of the future which uses alternating current. It has served its time in the system layout and must pass, because it is no longer needed as a functional device. Instead of the substation there will be unit generators, an a-c. grid distribution system, multiple-transformer vaults underground and synchronizing at the grid. It is a simple and reliable system because all faults clear themselves if small cables are used to tap the network, no large concentration of energy is had in generating stations, system stability is a maximum and service is also a maximum owing to the simple layout and multiplicity of supply points. When several generating stations are used, there is no problem of tie cables or of load and wattless control. The system becomes the old Edison grid system, which has proved to be the most reliable system of supply and lacks only the storage battery to be comparable to the best d-c. supply system.—*Electrical World.*

Abridgment of

High-Speed Recorder

BY C. I. HALL[1]

Fellow, A. I. E. E.

Synopsis.—This paper describes a new electrical instrument for automatically recording variations of electrical functions at high speed. The rate of chart motion is lower than that of the oscillograph so that the envelope of an a-c. wave is produced. This recorder has been successfully applied in the analysis of breakdowns on transmission lines, giving data used as the basis of securing improved selective relay protection and for other problems involving automatic high-speed recording.

Introduction

THE rapid adoption of interconnection and the formation of complex power networks have made it increasingly difficult to provide adequate relay protection for these systems. The location and settings of selective relays must be such that overloaded or faulty lines are promptly isolated and cut off with a minimum of interference to the service continuity of the remainder of the system. The high-speed recorder is an instrument which has been designed particularly as an aid in the solution of these problems. It has been built in a variety of forms having either one or more recording elements and giving either maximum values only, or records having a time base. It is started automatically by the excessive current incident to the fault and begins to record in approximately 0.03 sec. In its four-element form, it gives simultaneous records of the neutral ground current and each phase-voltage, for a period of 10 sec. after the occurrence of the fault. This covers the life of the disturbance, since the faulty section is usually cut off in a few seconds by the protective relays.

Although the high-speed recorder was designed primarily as an aid in the study of line faults, it is obvious that it has numerous other applications, some of which are mentioned later. The recorder may be used in nearly any application in which automatic starting or high-speed recording is necessary.

The use of the recorder in analyzing transmission line faults has been described by E. M. Tingley in a paper entitled *The Hall High-Speed Recorder*.[2] Included in this paper were numerous records made in service on the system of the Commonwealth Edison Company. The purpose of the present paper is to deal particularly with the design and construction of the recorder, including sufficient test records to illustrate the varied application of the instrument.

Requirements of Recorder

The design of the recorder incorporates the following features, which are considered essential to a device of this class:

a. Automatic operation: Recording is started by a high-speed relay actuated by increase in line current or other determining variable.

b. Speed of recording: The record shows values for each half cycle on 25- and 60-cycle circuits.

c. Minimum delay before beginning to record: The total time after occurrence of the fault until the device begins to record is approximately 0.03 sec. It is obvious that this lag must be short in order that no part of the record be lost.

d. Sturdy construction: Comparable to portable ammeters and voltmeters. The instrument contains no delicate parts which are likely to become damaged with ordinary handling and care.

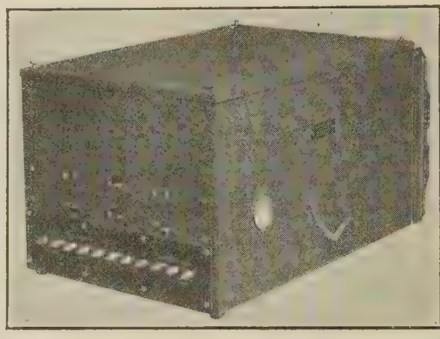

Fig. 1—General View of Four-Element Recorder

e. Portability: The recorder may be easily moved about from place to place, and set up in condition for recording.

f. Improved light source: The light source is more effective and efficient than types used heretofore. An intensely brilliant point of light is produced on the recording film, yet the input is low, so that dry cells can be used as a power source.

g. Daylight loading: Standard photographic film holders are used, enabling loading and unloading in daylight as with an ordinary camera.

Classes of Recorders

As previously mentioned, the recorder has been produced in both four-element and single-element form.

1. Engineer, General Electric Co., Fort Wayne, Ind.

2. *The Hall High-Speed Recorder*, E. M. Tingley, 1928 Quarterly Trans., No. 2, Vol. 47, p. 252.

Presented at the Regional Meeting of the A. I. E. E., Northeastern Dist. No. 1, New Haven, Conn., May 9-12, 1928. Complete copies upon request.

Views of the former device are shown in Figs. 1 and 2 while the latter is shown in Figs. 6 and 7.

Fig. 3 shows a chart obtained from a four-element recorder in service on the lines of the Commonwealth Edison Co. The upper record of this chart gives the variation in neutral ground current while the three lower records give voltage values on the three phases.

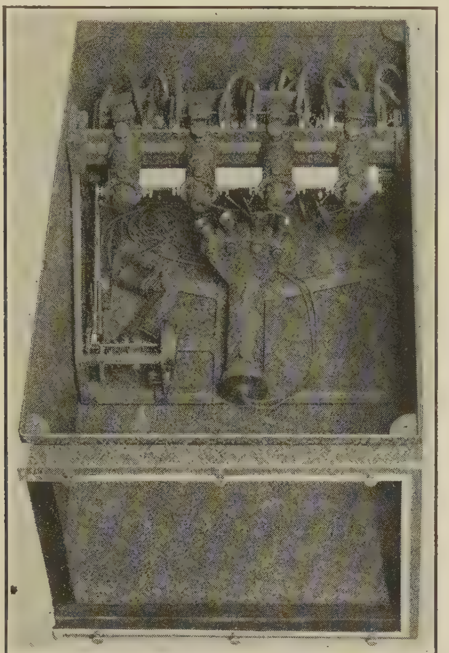

Fig. 2—Interior of Four-Element Recorder

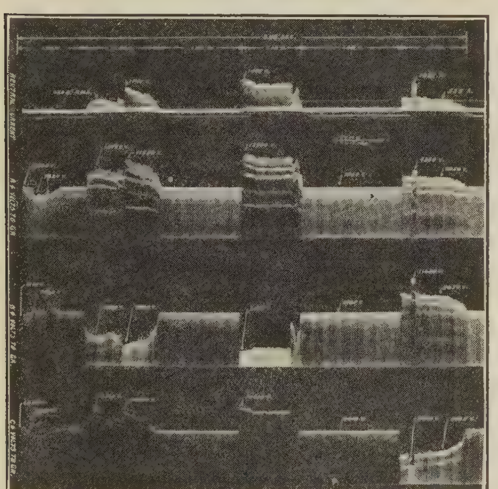

Fig. 3—Record Made by Four-Element Recorder on System of Commonwealth Edison Company

Ordinates represent current and voltage values, and time movement is from left to right.

Fig. 8 gives a group of four calibration records made with a single-element recorder of the stationary film type. With this construction, maximum values only are recorded. The single-element recorder has been arranged also to give time-base records by the application of a separate moving film mechanism.

Light Source

A side view of the four-element recorder drawn schematically is shown in Fig. 4. This cut also illustrates the type of light source used in all recorders.

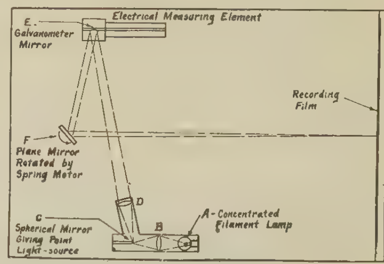

Fig. 4—Schematic Diagram of Light Source and Optical System, Four-Element Recorder. (Side View)

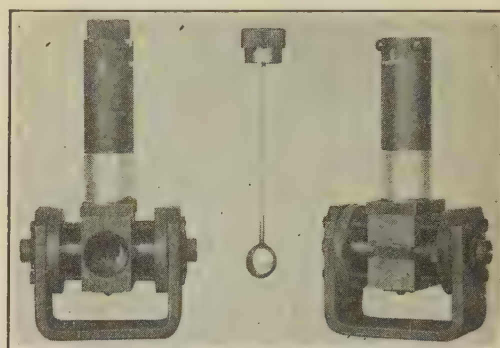

Fig. 5—Electrical Measuring Element. Front and Rear Views and Vane Only

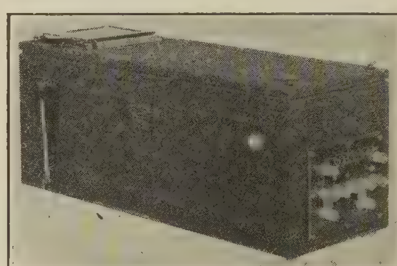

Fig. 6—General View of Single-Element Recorder

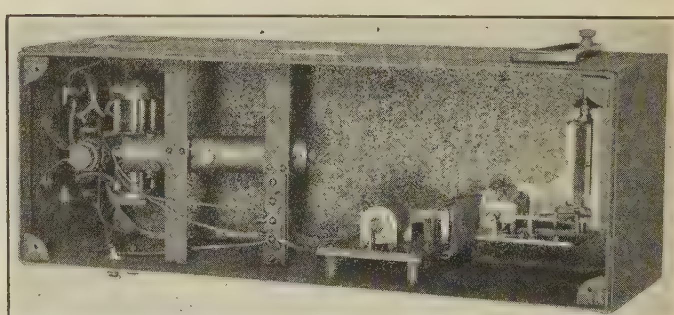

Fig. 7—Interior of Single-Element Recorder

A small concentrated filament automobile type lamp, *A*, is placed in one end of a light-tight tube which also contains lenses *B* and *D* and a highly polished metallic hemispherical mirror *C*. The rays from the lamp are

focused upon the hemispherical mirror, which, through reflected light, becomes a secondary light source of very small diameter and high intensity. The rays from this secondary source pass through lens D to the galvanometer mirror E, from which they are reflected to plane mirror F and thence are focused upon the recording film. During the time of recording, the plane mirror F is rotated at a definite rate in the direction indicated by the arrow by a governor-controlled spring motor. This rotation of mirror F causes the recording point of light to move across the stationary film at the rate of 1 in. per sec. Only one lamp and secondary source are required for all four recording elements, as four lenses D, located in an arc of a circle above C and transmitting light to four individual

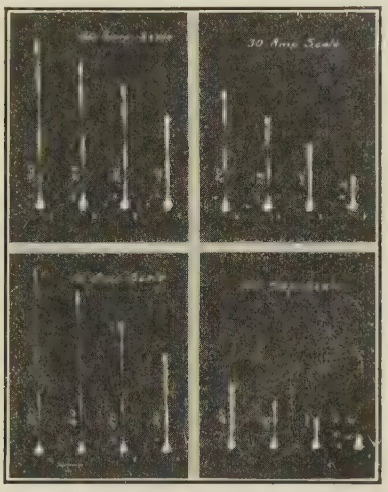

Fig. 8—Calibration Records Made With Single-Element Recorder

galvanometer mirrors are used. This will be understood by referring to Fig. 2.

Electrical Element

A detailed view of a recording element is shown in Fig. 5. This element consists of a soft iron yoke supporting two adjustable poles which carry the winding. The moving element is a soft iron vane, mounted rigidly on the end of a stiff duralumin rod and set at an angle of 45 deg. to the flux path between the poles. An aluminum support riveted to the vane carries a galvanometer mirror and a guide bearing pivot. The vane and mirror assembly is shown between the front and rear views of the complete element. For use on a-c. circuits the electrical elements are connected to the lines through transformers contained within the recorder. In this way, proper ratings are obtained and a standard element can be used for recording either current or voltage. When d-c. circuits are being studied, the transformers are replaced by special external shunts.

The moving system or vane is of low inertia and high period of oscillation, so that it readily follows changes during each half cycle. The construction is very sturdy and the element is not liable to damage in shipment and handling. The light beams and photographic film used in recording eliminate the inertia inherent in other methods of recording.

Operation

As indicated earlier, the high-speed recorder begins operation automatically upon the occurrence of an overload, or fault. This is accomplished through a high-speed current-operated relay which is continuously connected in the neutral ground circuit. The high-speed relay for the four-element recorder is contained in a separate case, while that for the single-element device is contained inside the case of the recorder proper.

In operating, the high-speed relay energizes three small contactors which connect the voltage elements to the line. The high-speed relay also turns on the recording lamp and releases a constant speed spring motor which rotates the plane mirror F of the four-element recorder or advances the film in the single-element recorder. At the end of the recording period a contact is opened by the spring motor which completely deenergizes the recorder control circuit, turning off the light source and disconnecting the recording elements. The operator, upon arrival, renews the film, rewinds the spring motor and releases a latch in the high-speed relay. The recorder is then ready for operation again, and the exposed film is taken into a dark room for development.

Records

The size of record furnished by the four-element recorder is 11-in. by 14-in., and is made on standard film. The records made by the single-element recorder, stationary film type, are 3¼-in. by 4¼-in. and are also made on standard film. The single-element recorder for moving film uses standard 3¼-in. by 5½-in., 12-exposure kodak film.

Scales

Standard deflection scales are as follows:

a. Four-element device
   70 volts per in.
   5 amperes per in.
b. Single element (ammeter)
   On 30 ampere coil —10 amperes per in.
   On 60 ampere coil*—20 amperes per in.

Time Lag of Relay and Lamp

It is important that the time required for the high-speed relay to operate and for the lamp filament to reach recording brilliancy be very short, in order that the record may cover the complete disturbance. Tests have shown these time lags to be as follows:

*Note. The ammeter coil of the single-element recorder is equipped with taps so that if desired, only one-half of the winding may be used, thus doubling the current capacity of the instrument.

a. Lag of High-Speed Relay on 60 Cycles

Per cent of critical current	Time in sec.	Cycles at 60 ~
150	0.0058	0.348
200	0.0035	0.210
500	0.0020	0.120
1000	0.0012	0.072
2000	0.0010	0.060

b. Lag of Recording Lamp

Lamp rating	Volts applied	Time in sec. for lamp to begin to record	Cycles at 60 ~
18-24 v., 27 cp. auto headlight.	35.5	0.027	1.62

c. Total Time to Begin to Record (Sum of lags of high-speed relay and lamp)

Per cent of critical current	Time in sec.	Cycles at 60 ~
150	0.033	1.97
200	0.031	1.83
500	0.029	1.74
1000	0.028	1.69
2000	0.028	1.68

Miscellaneous Applications

The possible applications of this type of instrument are numerous and varied. Figs. 9 and 10 show test records made using slight modifications of the standard recorder in order to give a time scale of 5 in. per sec. and also to add a timing indication to the chart. The latter was done by focusing the rays of a small high-speed filament hydrogen-filled lamp on the lower edge of the film. This lamp was operated by a 60-cycle supply circuit and thus produced on the record a row of timing dots 1/120 sec. apart.

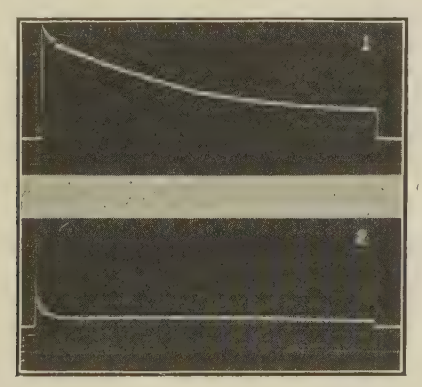

Fig. 9

1. 20-Ampere load applied to 1-kw., 150 volt, d-c. motor-generator set.
2. Starting current of 200-watt Mazda C lamp.

Chart 1, Fig. 9, shows the variation in current following the application of a 20-ampere load to a 150-volt d-c. line supplied by a small 1-kw. motor-generator set. The record shows how the current rose at once to a maximum value and then tapered down gradually, owing to a reduction in speed of the overloaded motor-generator. The detail of the record is exemplified by the small variations in the record line caused by sparking of brushes. The timing dots show that the complete interval during which the circuit was closed was 1.2 sec.

Chart 2, Fig. 9, shows the starting current of a 200-watt Mazda C lamp, indicating the initial rush of current with cold filament and the reduction in value as the filament becomes heated.

Fig. 10 shows the blowing of plug and cartridge fuses under various conditions on a 220-volt d-c. circuit. In each chart, ordinates represent current values and time reads from left to right. Chart 1 was made by a 6-ampere plug fuse connected in series with a 20-ampere resistance load. The fuse blew in approximately 0.75 sec. and the arc was extinguished quickly. Chart 2 was made by another plug fuse of the same rating and with the same current value, but using an inductive rather than a resistance load. It will be noted that in this case the current value builds up more gradually and that an arc continues for about 0.35 sec. after the fuse wire has melted.

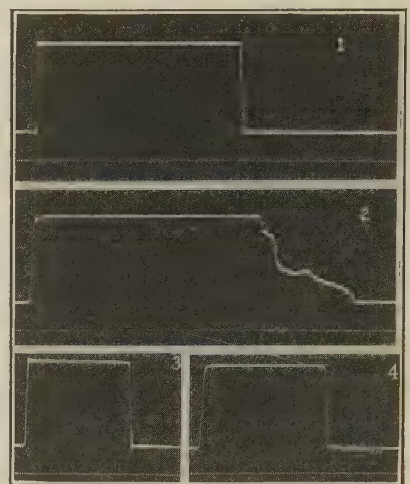

Fig. 10—Blowing of Fuses on 220-Volt D-c. Circuit

1. 6-Ampere plug fuse on 20-ampere resistance load
2. Same as "1" except inductive load
3. 5-Ampere cartridge fuse on 20-ampere resistance load
4. Same as "3" except inductive load

Chart 3, Fig. 10, shows the blowing of a 5-ampere cartridge fuse on a 20-ampere resistance load. Chart 4 shows the same conditions except for the substitution of an inductive load. It will be noted that the cartridge fuse opened the inductive current without the formation of an arc.

Other suggested uses for the high-speed recorder include the investigation of starting currents of motors, motor current values on high overloads of short duration, brief reductions in line voltage due to starting of motors or other high-current loads, and general laboratory investigations where the device may be used for visual readings or permanent records.

Abridgment of

Shunting of Track Circuit in a Polyphase System of Continuous Inductive Train Control

BY C. F. ESTWICK[1]

Member, A. I. E. E.

Synopsis.—Investigations into shunting of train control track circuits have been made in the field under operating conditions by observing the operation of the primary relay on a locomotive as a train runs into a track circuit in which there is a train ahead or an open switch and similar data have been obtained on the performance of the relay on trains in regular service.

It is intended in this paper to present a method for predetermining the shunting characteristics of train control track circuits. The system discussed is a polyphase system of continuous inductive train control with cab signals employed on double-tracked steam roads. Curves are given which describe shunting conditions in train control track circuits and data are also given for comparison describing the shunting of the track relay on the same sections of track.

IN a system of continuous inductive train control the apparatus on the trains on a steam-operated railroad is located on the locomotive or tender and consists of a receiving system, visual cab signals, a train controlling mechanism that operates in connection with the automatic air-brake equipment on the train and auxiliary apparatus which includes an acknowledging contactor and audible signals. The train controlling mechanism limits the speed of the train at all times to certain predetermined speeds which depend upon traffic conditions and the distance a train has traveled in a block. A failure on the part of the engineman properly to control the speed of the train results in an automatic application of the brakes as soon as the maximum allowable speed has been exceeded. After an automatic application has been made the brakes cannot be released until the speed of the train has been reduced below the maximum speed. When a train is traveling on clear track a clear signal indication is given in the cab and the speed of the train is limited to a safe speed, which in the case of a passenger train may be 70 mi. per hr.; when the train enters a caution block the cab signal changes, giving a caution or medium speed indication, and the automatic controlling mechanism operates to enforce a gradual reduction in speed until the speed has been reduced to below 20 mi. per hr. at the exit end of the block. As a train passes from a caution into an occupied block the signal changes to a danger or slow-speed indication and the limitation of 20 mi. per hr. is maintained as long as the block is occupied by a train ahead.

The cab signals and speed controlling mechanism are under the control of a three position a-c. primary relay. When the train is traveling under clear conditions the relay is in its normally energized position; when the train passes into a caution block the relay operates to the reverse position, and when it is in an occupied block or a block in which there is an open switch the relay assumes its deenergized position and releases the normal or reverse contacts. The primary relay is under the control of an influence obtained inductively, by means of receivers on the locomotive, from alternating current flowing in the rails of the track.

The apparatus along the track includes the usual a-c. track circuit modified slightly for train control purposes, and upon this is superimposed a so-called "line circuit." The actual current flowing in the rails consists of two components of current, one due to a

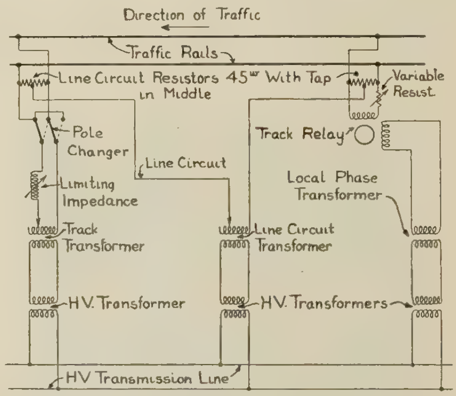

FIG. 1—TRAIN CONTROL TRACK CIRCUIT

voltage impressed on the circuit from the track circuit transformer and the other due to voltage from a transformer in the line circuit. These two components of currents will be considered separately and will be referred to hereafter simply as "track circuit current" and "line circuit current." The wayside circuits are shown schematically in the diagram in Fig. 1 and may be traced as follows:—Track circuit current flows from the track circuit transformer which is located at the exit end of the block through a limiting impedance and a pole changer to one of the rails of the track, along the rail to the opposite end of the block through a variable resistance unit and windings of the track relay to the other rail, back along the rail and through the pole changer to the transformer. The relay is normally

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energized by current flowing in the track and local windings as shown in the diagram; the track windings receive current from the rails and the local windings are energized by current from the local phase transformer. The track relay is the usual a-c. rotor type relay employed in railroad signaling which operates in three positions and requires the use of the pole changer in the track circuit to give normal and reverse operation. The normal and reverse control also permits of three position operation of the primary relay which is a similar two element relay of the rotor type. When a block is occupied by a train the current in the rails flows from one rail to the other through the wheels and axles of the train, and on account of the very low impedance of the path through the wheels and axles most of the current is shunted from the track relay which causes it to become deenergized sufficiently to release its front contacts. Circuits through the relay contacts control the operation of wayside signals in the usual manner. Line circuit current flows from the line circuit transformer to the middle point of a comparatively high resistance bridged across the rails at the relay end of the block, through the two halves of the resistance and along the rails of the track in multiple, through a similar resistance at the other end of the block to the middle point of the resistance unit, and through a line wire back to the transformer. From the description of the circuits it is evident that track circuit current flows away from the transformer on one rail of the track and back on the other rail, that is, the current flows in opposite directions in the two rails, whereas the line circuit current is evenly divided between the rails and flows in the same direction in each rail. The track circuits are adjusted for normal operation under clear or caution conditions so that there will be 0.8 ampere in the rails at the relay end of the circuit as a train enters the block, and the line circuit is adjusted to give total line circuit current 0.8 ampere or 0.4 ampere in each rail.

There are two receivers located on the locomotive just ahead of the front wheels called track circuit receivers, and a similar pair of receivers farther back on the locomotive or on the tender known as line circuit receivers. The receivers are supported a few inches above the rails of the track, and coils in each pair of receivers are connected in series. The connections are such that on account of the direction of the flow of current in the rails the track circuit receivers are energized inductively by track circuit current and are not influenced by line circuit current, and the line circuit receivers are energized by line circuit current and are not affected by current in the track circuit. There is a two-circuit vacuum tube amplifier with four tubes employed in the locomotive equipment to amplify the small voltages induced in the receiver coils. The input circuits of the amplifier are connected separately to the front and rear receivers and the output circuits are connected to corresponding windings of the primary relay. The amplifying apparatus is carefully adjusted so that when the track circuit and line circuit currents in the rails are in time phase the currents in the relay windings will also be in phase, in which case no torque will be developed on the rotor shaft of the relay. If the phase of the current in either the track circuit or the line circuit is varied the corresponding current in the relay follows the phase of the rail current. The phase displacement between the currents in the relay windings under any condition of operation is therefore the same as the phase displacement between the currents in the rails. The size of the current in the relay windings relative to the corresponding rail currents are shown in Fig. 2 of the complete paper.

Conditions of the Track. The rails of the track are A. S. C. E. section, 100 lb. per yd., bonded with two No. 6 copper-clad bond wires 54 in. long, having a loop impedance 0.25 ohm per 1000 ft., power factor 0.5., and the ballast is mostly stone ballast having a resistance varying between 5 ohms and 20 ohms per 1000 ft. of track. The leakage resistance of two rails in multiple to ground is taken as 2 ohms per 1000 ft. in wet weather and 12 ohms per 1000 ft. in dry weather. The length of the track circuit is 6000 ft.

Characteristics of the Track Relay. Local Phase: Impedance 440 ohms, power factor 0.656; current at 110 volts, 0.25 ampere; phase of current relative to voltage $\angle$ 49 deg.

Track Phase: Impedance 0.64 ohm, power factor 0.656; operating currents with 90 deg. phase displacement. Current to pick up relay to make front stop, 0.22 ampere. Current to pick up relay to close front contacts, 0.19 ampere. Current to allow relay to release its contacts, 0.11 ampere.

Adjustment of the Track Circuit. On a steam operated road without train control the track circuit would be adjusted under wet weather conditions with a limiting impedance of 4 ohms, but with this adjustment when a train is entering the block there would not be the required current 0.8 ampere in the rails for the operation of the train control equipment. To increase the current in the rails the amount of limiting impedance might be reduced, but it would be better for the purpose of improving the shunting to retain the 4 ohms limiting impedance and increase the voltage on the track transformer to give 0.88 ampere (*i. e.,* 0.8 ampere + 10 per cent to allow for drop in transmission line voltage) and insert a variable resistance in series with the track relay as shown in Fig. 1 to limit the current in the relay sufficiently to give satisfactory normal operation. The voltage will have to be adjusted to 7 volts, which gives 0.875 $\angle$ 106 deg. 41 min. ampere in the rails as a train enters the block. The variable resistance in series with the relay is then adjusted when the block is unoccupied to 1.75 ohms giving 0.316 $\angle$ 101 deg. 24 min. ampere in the relay (equivalent current at 90 deg. phase displace-

ment 0.25 ampere). With this adjustment in dry weather when the ballast resistance is 20 ohms per 1000 ft. the current in the relay will increase to 0.706 ∠ 75 deg. 7 min. ampere (equivalent current at 90 deg. phase displacement 0.311 ampere) and the current in the rails at the relay end of the circuit as a train enters the block will be 1.185 ∠ 85 deg. 34 min. amperes.

Shunting of the Track Relay. Ordinarily, with a properly adjusted track circuit when a train enters a block the track relay becomes shunted, but in the case of a poorly adjusted circuit, under adverse rail conditions it might happen that the relay would not shunt, or if the relay shunts properly, as a train enters a high shunting resistance might allow the relay to pick up and the train loses its shunt. To determine the shunting characteristics of the track circuit, calculations have been made which show the maximum shunting resistance which will cause the relay to release its contacts and also the resistance which will just allow the relay to pick up again as the train passes through the block. The curves 1 and 3 in Fig. 3 show the maximum shunting resistances for different positions along the track throughout the entire length of the block which will cause the relay to release its contacts, and curves 2 and 4 resistances which will allow the relay to pick up to just close its front contacts.

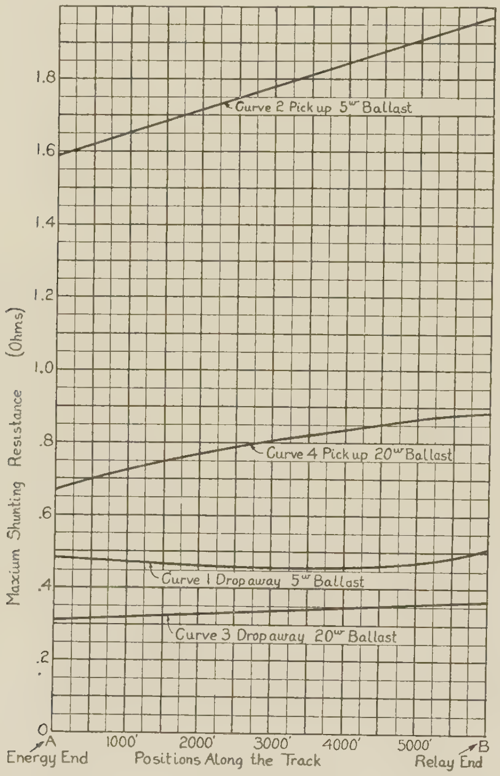

FIG. 3—MAXIMUM SHUNTING RESISTANCES AFFECTING THE TRACK RELAY AS A TRAIN PASSES THROUGH THE BLOCK

In Table I[2] numerical values are given of the data shown on the curves and also values of current in the relay when the corresponding maximum shunting resistances are connected across the rails. The formulas employed in calculating these maximum shunting resistances at intermediate positions in the block are given in Appendix I.

2. For all references to tables and appendixes see complete paper.

Characteristics of the Primary Relay. Operating torque on rotor shaft with 90 deg. phase displacement:

To cause sector to operate to front stop 0.45 in.-oz.
To pick up to just make front contacts 0.38 in.-oz.
To release front contacts 0.24 in.-oz.

The relation between torque and currents in the relay is expressed by the following equation:

$$T = I_L I_T K \sin \phi$$

Where T = Torque on rotor shaft
I_L = Current in line phase
I_T = Current in track phase
ϕ = Difference in phase between I_L and I_T
K = 4500

The value of K is practically constant for all operating conditions.

If the size of the line circuit current in the rails is known at any position on the track the operating current in the rails in the track circuit can be determined at 90 deg. phase displacement to produce any required torque in the primary relay.

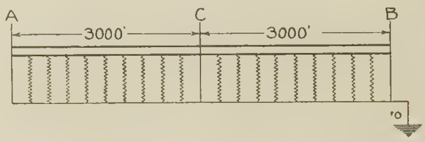

FIG. 4—EVENLY DISTRIBUTED LEAKAGE BETWEEN TWO RAILS IN MULTIPLE AND GROUND

Current in the Rails under the Receivers. Most of the current in the line circuit flows through the rails in multiple, but there is a small amount of current that flows through the ground, as shown in Fig. 4. The leakage current flows from the rails to ground in one-half of the circuit from A to C and flows back from the ground into the rails in the other half of the circuit from C to B. Tests have been made in the field of the amount of current flowing in the rails throughout the length of a block with a vacuum tube testing apparatus used in connection with a search coil on a laminated iron structure that was placed over the rail. The curves obtained show that the current in the rails follows very closely to the shape of the common catenary or cosh curve, and for that reason the conductance to ground is assumed to be evenly distributed and line circuit currents have therefore been computed from well known hyperbolic formulas. Calculations have been made of the line circuit current in the rails at different positions along the track and the results are given in Table II. The table also shows corresponding values of current in the relay taken from the curves in Fig. 2.

In this discussion the data in Tables II and III have been employed in connection with formulas given in

Appendix II in making calculation of the shunting characteristics of the circuit.

Shunting of the Track as Affecting the Primary Relay. Two conditions of shunting have been considered: first, with a forward train the middle of the block and the following train entering and approaching the train ahead; second, with a forward train at the exit end of the block and the rear train entering and proceeding into the block. In each case calculations have been made to determine the maximum shunting resistance through the wheels and axles of the forward train which

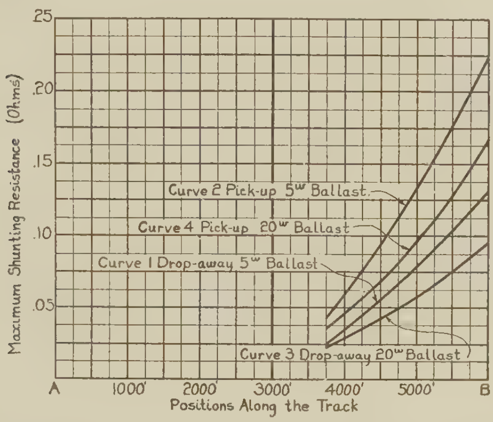

Fig. 6—Curves Showing Maximum Shunting Resistances When Forward Train is in the Middle of a Block and a Following Train is Entering and Approaching From the Relay End

will cause the pick-up or the drop-away of the primary relay on the rear train when the ballast resistance is 5 ohms and also when it is 20 ohms per 1000 ft. of track. The results of the calculations are plotted in curves in Figs. 6 and 7. Curves in Fig. 6 are for the case where the forward train is in the middle of the block and Fig. 7 where the forward train is at the leaving end of the block. In both figures curves 1 and 2 show the maximum resistances of the shunt of the forward train which will prevent the relay on the rear train from picking up and the resistances which will cause the relay to drop away respectively when the ballast is 5 ohms per 1000 ft., and curves 3 and 4 give the maximum resistances when the ballast is 20 ohms per 1000 ft. Numerical data from which these curves are plotted and also corresponding values of track circuit current in the rails under the receivers on the rear train are given in Tables IV and V.

The method of making these shunting calculations in train control track circuits is described in Appendix II.

Conclusions

In Fig. 3 the curves 3 and 4 describe the shunting of the track relay as a train passes through the block during dry weather conditions. The resistance of the shunt must be less than 0.366 ohm, as shown on curve 3, when the train enters the block to cause the relay to release its contacts and as the train proceeds the resistance must remain less than the resistances shown on curve 4 to prevent the relay from picking up. If the relay should pick up, the shunting resistance must decrease again below the values shown on curve 3 to cause the relay to release its contacts.

The curves in Figs. 6 and 7 describe the shunting requirements for safe operation of the train control equipment. For instance, during dry weather conditions when there is a train in the middle of a block and a following train is entering the block, curve 3 in Fig. 6 shows that the resistance of the shunt of the forward train must be less than 0.096 ohm to cause the primary relay on the rear train to release its contacts and the resistance must remain less than the values shown on curve 4 to prevent the relay from picking up as the train proceeds into the block. If the relay should pick up the shunting resistance must be reduced to a value less than those shown on curve 3 to cause the relay to drop away again.

In the ordinary track circuit, the wheels of a train shunt out the track relay in series with the rails of the track; but in the case of a forward train shunting current from a rear train, there is only the impedance of the rails between the two trains and the impedance through

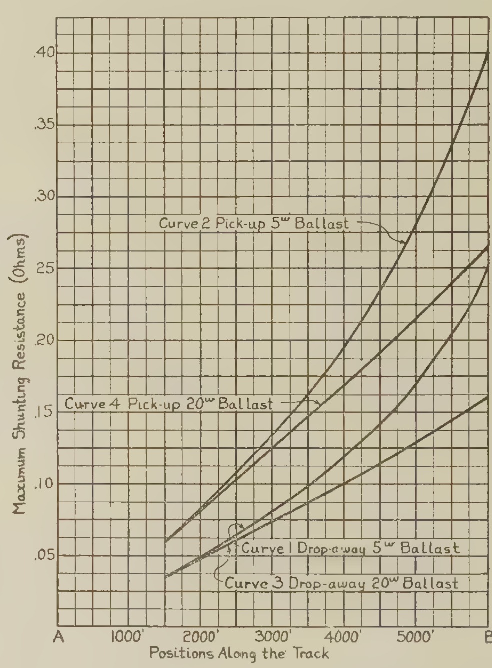

Fig. 7—Curves Showing Maximum Shunting Resistance When Forward Train is at the Energy End of a Block and a Following Train Entering and Approaching From the Relay End

the wheels and axles of the rear train to be shunted. The effect of the shunting on the primary relay is not so good as the shunting of the track relay, and the shunting effect on the primary relay on a following train becomes poorer as the train runs closer to the train ahead.

In short train control track circuits the condition of the ballast has little effect on the shunting of the primary relay; but in longer circuits, a mile or more in length, the ballast resistance has a considerable effect. The curves show that the shunting is better during wet weather than it is under dry weather conditions.

Marine Work

ANNUAL REPORT OF COMMITTEE ON APPLICATIONS TO MARINE WORK*

To the Board of Directors:

The activities of the Committee on Applications to Marine Work this year were devoted chiefly to the dissemination of the Marine Standards (A. I. E. E. Standard No. 45), cooperation with the N. F. P. A. (Committee on Fire Detection and Alarm), cooperation with the American Marine Standards Committee on specifications for water tight receptacles and the expenditure of further efforts to induce the U. S. Steamboat Inspection Service to recognize and properly classify the electrical engineer on shipboard.

A. I. E. E. Standards No. 45 were issued in June 1927. The committee this year made a special effort to distribute the Standards to all departments of the marine industry likely to be interested and as a result of this campaign 750 copies were sold.

The Standards are recognized and accepted by the various marine classification and insurance societies, naval architects and marine engineers, and are incorporated as one of the regulating provisions in their specifications. A. I. E. E. Standards No. 45 are therefore a recognized success and will serve to standardize the electrical installations on shipboard and to stimulate the use and proper care of electrical machinery in the marine field.

The Conference Committee on Fire Detection and Alarm requested our cooperation in connection with recommendations which it was preparing for the Steamboat Inspection Service, of fire alarm and fire detecting systems. In compliance with this request, our committee reviewed its proposed recommendations in detail and subsequently held a joint meeting with its representatives, at which all points of difference were discussed.

The committee also cooperated with the special committee on water tight receptacles appointed by the American Marine Standards Committee of the Bureau of Simplified Practise, to draw up specifications for water tight receptacles for shipboard service.

Considerable time was spent in connection with the proposition of inducing the U. S. Steamboat Inspection Service to make provision in its regulations for the proper rating and classification of the electrical engineer on shipboard. To this end, our committee prepared its report containing a statement of the status of the present electrical personnel, reasons for higher and proper rating and recognition of the electrical engineer on board ship, together with a suggested list of ratings and grades for the electrical personnel of the various classes of ships. These recommendations were made in such manner as to permit licenses in the different electrical grades being taken out by those of the present steam and Diesel classified engineers who qualified.

This report was presented by our subcommittee on personnel at the annual meeting of the U. S. Steamboat Inspection Service in Washington in January. Although final action was deferred by the Steamboat Inspection Service at its annual meeting, it decided to take our recommendation under consideration in the regular routine of its body and prepared plans to circularize the marine operators for the purpose of soliciting their opinions in the matter of classifying electrical personnel. It is felt that favorable action will be taken by the Steamboat Inspection Service and its regulations modified in the course of time. Our subcommittee on personnel is keeping in close touch with the situation.

In addition to the above chief items considered by the committee this year, the question of revision of present specifications was taken under advisement and arrangements made to automatically keep the specifications up to date by considering and acting upon all proposed changes as they are presented. In this way the time and effort required to get out the revised issue when necessary will be considerably minimized.

The outstanding electrical developments in the marine field during the past year are as follows:

1. The construction of five 3000-ship hp. turbine-electric drive U. S. Coast Guard Cutters.
2. The placing in service of the S. S. *California* an 18,000-ship hp. twin-screw turbine-electric drive passenger ship for the Panama Pacific Steamship Line. A sister ship to the *California* is now under construction.
3. The conversion by the U. S. Shipping Board of three of their largest cargo vessels (*Courageous, Defiance* and *Triumph*) to Diesel electric drive. These vessels will have machinery suitable for 4000 ship hp. normal and 4500 ship hp. maximum continuous.

Besides the above chief developments there have been a number of smaller craft equipped with electric propulsion. The application of electrical equipment to ships is continuing at an increasing rate and the future looks hopeful indeed.

With the passage of the Jones-White bill and its approval by the President, the American Merchant Marine has received its first real encouragement since the World War period. This bill contains several provisions which will undoubtedly stimulate the American marine industry. We can anticipate rapid developments in which electricity will play a very important role.

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*APPLICATIONS TO MARINE WORK:

W. E. Thau, Chairman,
R. A. Beekman, Vice-Chairman.
J. L. Wilson, Secretary,

Edgar C. Alger,	J. S. Jones,	Wm. H. Reed,
H. C. Coleman,	A. Kennedy, Jr.,	Edgar P. Slack,
E. M. Glasgow,	J. B. Lunsford,	H. M. Southgate,
H. Franklin Harvey, Jr.,	E. B. Merriam,	C. P. Turner,
Wm. Hetherington, Jr.,	I. H. Osborne,	Oscar A. Wilde,
H. L. Hibbard,	G. A. Pierce,	R. L. Witham.

Presented at the Annual Convention of the A. I. E. E., Denver, Colo., June 25-29, 1928.

Abridgment of

Automatic Voltage Regulators

Application to Power Transmission Systems

BY C. A. NICKLE[1] and R. M. CAROTHERS[1]

Associate, A. I. E. E Member, A. I. E. E.

WITHIN a relatively short time conditions in transmission systems as regards continuity of service and maximum power have radically changed. A few years ago, the amount of power transmitted over important lines was relatively small compared with their ultimate transmitting capacity. In such cases, the systems were inherently stable, and there was a reasonable margin of power with respect to load swings and short circuits. Automatic voltage regulators were used at that time chiefly for maintaining more uniform voltage conditions than could be obtained by intermittent adjustment by hand control. Different types of regulators for this purpose have given satisfactory service for a number of years. However, conditions have gradually changed. Within the last few years the power to be transmitted has increased to such an extent that it has now become necessary to consider means seriously for increasing the maximum power and for insuring continuity of service during transient disturbances, such as load swings and short circuits. The object of this paper is to present the results of an extended investigation along these lines. A new regulator is described which will accomplish the above purposes, and the theoretical analysis is confirmed by test results.

Factors Influencing Power Limits

In order to facilitate an understanding of the principles involved and the functions of voltage regulators and exciters in a transmission system, some of the factors which determine the power limit of a system will be considered briefly. When the shaft load of a synchronous motor connected to an alternator, directly or through a transmission line, is gradually increased, a point is soon reached where no more electrical power can be supplied to the motor. The amount of power which can be thus supplied depends upon the total reactance between the generator and motor, including their internal reactances, and upon the values of excitation which exist. Small values of excitation give small values of breakdown power, and large values give large values of breakdown power.

The magnitudes of the excitation which can be applied to the machines are limited by the condition that certain predetermined terminal voltages shall not be exceeded. For different sets of fixed excitation values there will be corresponding values of terminal voltages and power when breakdown occurs. Under these conditions of fixed field excitation, the maximum power obtained is termed the steady state or static power limit for those terminal voltages. For instance, if the power on a given system is 100,000 kw. when the machines pull apart, and if the terminal voltage is 220,000 volts at this instant, all excitations being held constant, then 100,000 kw. is the steady-state power limit for operation at 220,000 volts.

Under proper conditions of variable excitation it is possible, however, to operate beyond this limit. The first experimental evidence that this was practicable was obtained[2] by the use of devices which increased the excitation as a function of load current, and thus compensated for armature reaction simultaneously with its occurrence. While recognizing the advantage of such factors as mechanical inertia, damping, and electromagnetic transients in stabilizing operation during system disturbances, earlier investigation, including tests with existing standard commercial regulators, had nevertheless not brought out the full possibility of utilizing these factors in producing stable operation above the steady-state limit. Indeed they definitely showed that even if it were possible to hold the machines in synchronism significantly above that limit, this was accompanied by prohibitive hunting. Later investigation, however, showed that stable operation beyond the steady-state limit was possible with control by a vibrating contact regulator having special and unique characteristics. This will be fully discussed later.

Dynamic Stability

When operating below the steady-state power limit, machines are inherently stable, *i. e.*, with no changes in the electrical constants, certain increments of shaft power may be applied without loss of synchronism, and the machines are thus considered to be in static equilibrium. For values of transmitted power above the static power limit, conditions are radically different.

Although equilibrium may exist for certain values of excitation, power, angular displacement, etc., nevertheless, if the excitations remain constant, any increase in shaft load increases the angular displacement with a resultant decrease in transmitted power. Thus, for this condition the rate of change of power with respect to angular displacement is negative, and any change in shaft load produces cumulative action. Fortunately, due to inertia of the moving parts, the damping action

1. Both of General Electric Co., Schenectady, N. Y.

Presented at the Regional Meeting of the A. I. E. E., St. Louis, Mo., March 7-9, 1928. Complete copies upon request.

2. Nickle and Lawton, *An Investigation of Transmission System Power Limits*, TRANS. A. I. E. E., 1926, Vol. XLV, p. 12.

of short-circuited rotor windings, and the tendency of the flux linking the field winding to remain constant, the process of falling out of step is relatively slow; and if the excitations are properly adjusted following a change in shaft power, the machines can be held in equilibrium.

Similarly, when a decrease in shaft power occurs, the angular displacement decreases with a resultant increase in transmitted power. For conditions of fixed excitation, the machines will thus continue to approach each other in phase position, and will come to equilibrium at a smaller angle for which the machines are inherently stable.

Dynamic stability may be further illustrated by considering the equations of the simple case of two identical cylindrical rotor machines connected directly together electrically.

The power as a function of the excitations or nominal

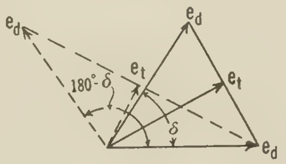

FIG. 1—VECTOR DIAGRAM FOR TWO IDENTICAL CYLINDRICAL ROTOR MACHINES ON THE SAME BUS

voltages (assumed to be the same on both machines) and the angular displacement between the rotors, is

$$P = \frac{e_d^2}{x} \sin \delta \qquad (1)$$

where

e_d = nominal voltage corresponding to the excitations on the generator and motor.

x = total reactance of both machines.

δ = the angular displacement between the rotors.

From this relation, it may be seen that the same power may be transmitted at two values of δ, *i. e.*, one angle δ' less than 90 deg., and another angle (180 deg. $- \delta'$) greater than 90 deg., for given values of excitation and reactance. The vector diagram is as shown in Fig. 1. From this figure, it is evident that the terminal voltage is different for these two operating angles and is given by the equation

$$e_t = e_d \cos \frac{\delta}{2} \qquad (2)$$

From the standpoint of power transmitted, it is thus immaterial whether operation occurs at δ', less than 90 deg., or at 180 deg. $- \delta'$, greater than 90 deg., for given values of nominal voltage. However, the terminal voltage will be less in the latter case, the comparison being cos (90 deg. $- \delta'/2$) or sin $\delta'/2$, with cos $\delta'/2$. Therefore if the terminal voltage is to be the same, we must operate at greater excitations at 180 deg. $- \delta'$ than at δ' and consequently more power can be delivered.

It is considerably more difficult to maintain equilibrium at 180 deg. $- \delta'$ than at δ' since the rate of change of power with angular displacement is negative and the machines are in a state of dynamic balance. Any increase in shaft power will cause breakdown if the excitations are not changed, and any decrease in shaft power will cause the angular displacement to revert to the inherently stable angular displacement, δ', with a resultant abnormal rise of terminal voltage.

Operation above the static power limit thus necessitates a continually varying excitation. What appears at the present time to be the most suitable means for properly controlling these excitations is an automatic voltage regulator of suitable design.

AUTOMATIC VOLTAGE REGULATORS

Automatic voltage regulators are of two general types, *i. e.*, the rheostatic type and the vibrating contact regulator. The characteristics of different regulators of the same general type may be essentially different, depending upon the constructional features and methods of control.

Before the introduction of automatic voltage regulators, voltage was controlled by hand adjustment of rheostats in the field circuits of the exciter or alternator. Such control is necessarily rather intermittent and it is evident that a regulator designed to perform the same functions as hand control, but more continuously,[3] would materially improve voltage conditions. The rheostatic type functions in this way, and for certain conditions of operation gives quite satisfactory service.

One of the advantages of such a regulator lies in the fact, that by suitable design, the entire regulator may be stationary for relatively long periods of time during steady load conditions, resulting in quietness of operation. The ratio of the time that the rheostat is in motion to the time that it is stationary is largely determined by the voltage sensitivity of the controlling relay. The greater the sensitivity of this relay, the smaller will be the voltage change required to operate the contacts and the motor-driven rheostat will be in motion a larger part of the time. With extreme sensitivity, the relays and motor-driven rheostat would be in operation all the time and the regulator would be essentially a vibrating contact regulator. The sensitivity of this relay has an important effect upon the possibility of such a regulator controlling operation above the static power limit.

When machines are operating above the static power limit they are continually in the incipient stage of breakdown. As they begin to break from synchronism, the terminal voltage changes are small, but if these small changes of terminal voltage are not corrected, the machines soon obtain sufficient velocity of separation to make it extremely difficult to restore them to equilibrium at a later instant, regardless of the speed

3. Doherty and Nickle, *Synchronous Machines*, TRANS. A. I. E. E., 1926, Vol. XLV, p. 927.

of build-up of the excitation voltage. In order that such a regulator may respond to these small voltage changes, the controlling relay must be made very sensitive to small voltage changes with the result that the regulator will be in operation at all times, even for power transmission below the static power limit. One of the advantages of this regulator is then lost, *i. e.*, still operation over relatively long intervals of time, and it becomes essentially a vibrating contact regulator.

A characteristic common to all vibrating contact

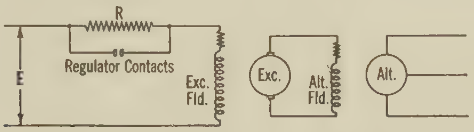

Fig. 2—Schematic Diagram of an Excitation System Controlled by Vibrating Contacts

voltage regulators is that the amount of excitation is controlled by periodically short-circuiting a resistance in the excitation circuit as shown in the simple diagram in Fig. 2.

When the contacts are closed all the time, maximum voltage is obtained at the exciter terminals, and when open all the time, minimum voltage is obtained. By varying the ratio of the time that the contacts are closed to the time that they are open, any value of average exciter voltage between these limits can be obtained.

There are different ways by which a vibrating contact regulator can change the average exciter voltage from one value to another. One method is to close the contacts at once and keep them closed until the desired

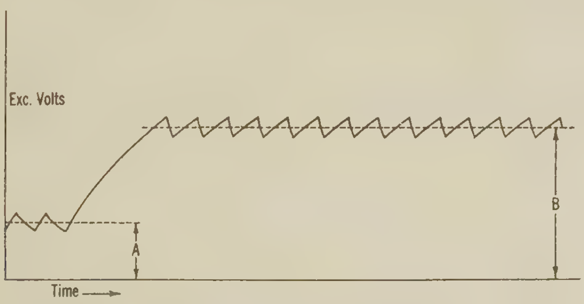

Fig. 3—Variation of Exciter Voltage as a Function of Time for the Case of a Sudden Drop of Alternator Voltage

Contacts close and stay closed until the new value of exciter voltage is reached

exciter voltage is reached, vibration then being resumed at the proper ratio of time-closed to time-open to maintain this new exciter voltage.

Another way would be to suddenly change the ratio of time-closed to time-open to a value which will ultimately sustain the new value of exciter voltage. It might seem that, since the ratio of time-closed to time-open is changed suddenly to a new definite value, the new average exciter voltage is immediately obtained. This, however, is not the case, the new average exciter voltage being obtained only after a relatively long transient. The equations for this transient are derived in the Appendix (see complete paper).

Although, in both cases, steps are taken at once to increase the average exciter voltage, nevertheless there

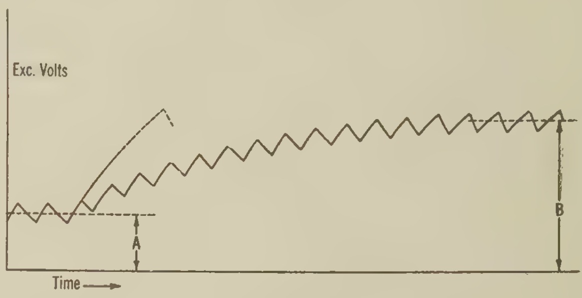

Fig. 4—Variation of Exciter Voltage as a Function of Time for the Case of a Sudden Drop of Alternator Voltage, When the Ratio of Time-Closed to Time-Open of the Contacts Suddenly Changes

is a marked difference in the time required to attain this new value. When the contacts close and remain closed until the new average exciter voltage is reached, the exciter voltage builds up at the inherent magnetic rate of the exciter, and, as a function of time, will appear as in Fig. 3. It is evident that for this case the maximum voltage rate possible is obtained from a given excitation system.

When the ratio of time-closed to time-open is merely

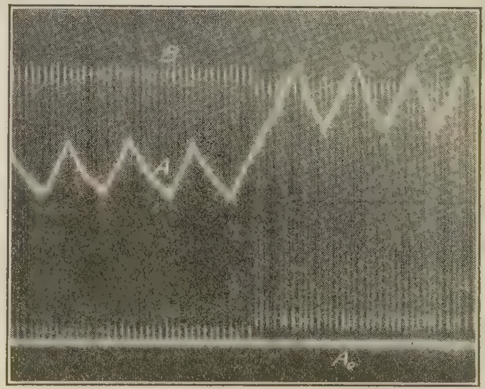

Fig. 5—Oscillographic Verification of Fig. 3, Using New Regulator

Curve A: Exciter voltage
Curve B: Alternator voltage

changed from one value to another, *normal vibration of the contacts is not momentarily interrupted*, and the transient appears as shown in Fig. 4.

The difference in time required for a given change of exciter voltage can be readily appreciated by inspection of Figs. 3 and 4. As seen from Fig. 4, any regulator which operates on the principle of suddenly changing the ratio of the time-closed to the time-open of the contacts, causes the rate of change of average exciter voltage to be very seriously reduced below its inherent or maximum rate, and is seriously handicapped for operation

under conditions of dynamic stability. In other words, such a principle used in a scheme of voltage regulation makes the effective voltage rate of the exciter much lower than the possible rate which might be obtained.

Oscillographic verification of the curves shown in Figs. 3 and 4 are shown in Figs. 5 and 6. In making these tests to determine the effect on the exciter voltage of a sudden small reduction in the a-c. voltage, a separate source of voltage, not controlled by the regulator, was impressed on the control coils. The relays of the regulator controlled the terminal voltage of an exciter in the usual way and the oscillograms were taken of the variation in exciter terminal voltage when the amplitude of the impressed voltage was suddenly decreased.

The difference in effective exciter voltage rate for the two cases, particularly for very small changes of impressed voltage, is so marked that a regulator operating on the first principle can effectively control machines in stable operation far above the static power limit, whereas a regulator operating on the principle of suddenly changing the ratio of time-closed to time-open of the relay contacts, gives about the same results as good hand control.

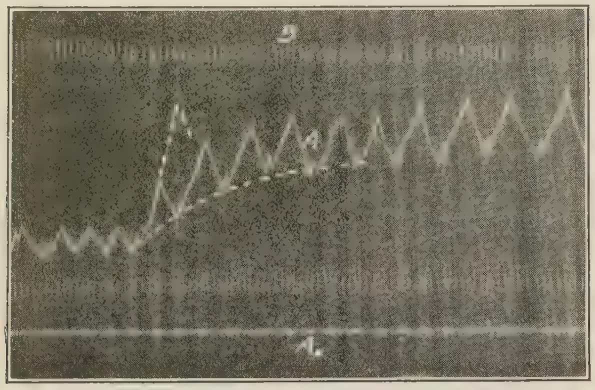

Fig. 6—Oscillographic Verification of Fig. 4, Using Regulator Without D-c, Coil

Curve A: Exciter voltage
Curve B: Alternator voltage

Short Circuits

Sudden disturbances, such as short circuits, result in a sudden drop in terminal voltage with a resultant loss of considerable synchronizing power for given conditions of angular displacement, fluxes, field currents, etc. Hence, at the instant a short circuit occurs, the angular displacement between the various machines begins to change and sufficient momentum may soon be acquired to cause loss of synchronism if corrective measures are not taken at once and as rapidly as possible.

Just as in the case of dynamic stability, inherent damping, inertia, and the tendency toward constant air-gap flux are favorable, their general effect being to increase the time required for breakdown to occur after a short circuit and in some cases they may, acting alone, prevent breakdown from occurring at all, if the short circuit is cleared in a reasonable time. In general, more time is permitted for excitation changes when these factors are large than when they are small.

However, such favorable factors which do exist do not seem to be sufficiently effective to allow the use of exciter voltage rates available in standard exciters, although these rates are sufficient for dynamic stability. This point is fully discussed in the companion paper by Mr. R. E. Doherty. As pointed out in that paper, the requirements of an excitation system to take care of short circuits are that the change of exciter voltage be initiated at once, and that it increase at a very rapid rate to the value which has been determined by the conditions of the particular case.

To fulfil the above requirements, the regulator must promptly close its contacts and keep them closed until the proper excitation voltage is reached, and the exciter voltage rate must be relatively high. Moreover, the regulator must not distinguish between phases—*i. e.*, it must act the same way regardless of the phase on which the short circuit occurs. Regulators which will accomplish this are commercially available.

If the a-c. voltage change is non-symmetrical, *i. e.*, different on the different phases, as in the case of single-phase short circuits, the response of a regulator controlled from one phase only will be different, depending upon the phase to which it is connected. In order that the regulator action shall be the same, regardless of the phase which is short-circuited, various schemes are available. One of them provides an actuating a-c. voltage for the regulator which is proportional to the positive phase sequence component of the three-phase line voltage. Another scheme, which is very effective, is to replace the usual a-c. voltage coil of the regulator by a small polyphase stationary torque motor, the shaft of which replaces the pivot of the right-hand lever. A dead short circuit on any phase then causes the torque of this motor to become zero, and therefore maximum effectiveness in increasing the exciter voltage is obtained.

AIRPLANE CARRIER LEXINGTON ESTABLISHES NEW RECORD

The Navy's airplane carrier *Lexington* established a new world record speed run of 700 nautical miles, covering the distance in 24 hours, at an average rate of speed of 29.2 knots, while en route from San Pedro, Calif., to Honolulu, the Department of the Navy was informed June 11 in a dispatch from Capt. A. W. Marshall, commanding the ship. The average speed of the vessel, when computed in land miles was about 33 mi. per hr.

The contract speed of the *Lexington* is 33 knots per hour. She has not yet been finally accepted by the Navy, in view of the removal of the last stages of the blading of the turbines of the vessel, which were found defective and will be replaced.

Mining Work

ANNUAL REPORT OF THE COMMITTEE ON APPLICATION TO MINING WORK*

To the Board of Directors:

In reviewing recent progress made in the application of electrical power in mines, one is inclined to conclude that it has been effected by the general economic conditions prevailing in the mining industry. Overproduction facilities in men and mines, labor problems, and freight rates are factors which are vitally influencing the prosperity and accomplishments of the business.

Conferences of mine managers and manufacturers of mining equipment, together with the meetings of engineering societies, indicate that the mechanization of mines is making great progress; in fact, definite conclusions have been reached that, under many conditions, mechanization pays. Considering the great investment required, and the new problems arising in the concentration of men, equipment, and supplies, creditable economies are being effected in the mechanical loading of coal where but an average tonnage is obtained from the equipment. Mine managers are realizing that the successful loading of coal is not solved by the purchase and installation of the machine, but that it involves many other operations, such as mining the coal, car dispatching, transportation, and mine planning. The question of cleaning the coal must also be included, since machine-loaded coal contains the impurities which, in hand loading, are left in the mine.

In 1926, about ten million tons of bituminous coal were loaded mechanically by 455 machines, this being an increase of approximately 60 per cent over 1925. While no complete reports are available at the present time concerning the number of machines in operation during 1927, certain information indicates that there will be a decided increase over those used in 1926. Due to the suspension of mining in Illinois and Indiana, the tonnage loaded in 1927 will not show much increase.

As the mechanization of mines continues, so does also the demand for equipment approved by the United States Bureau of Mines. This is due to the fact that much of the equipment required in mechanical loading and conveying machinery is used at the face workings where the maximum danger from gas and dust exists. The use of electrical equipment approved by the Bureau of Mines is becoming so general that there is in operation a bituminous coal mine with a daily output of 3500 tons, in which all of the underground electrical apparatus carries the permissible plate of the Bureau. Power for the motors in the mine is supplied by storage battery power trucks.

In some mines, mechanical loading means the use of several 125-hp. scraper hoist motors. A loading system of this type requires the transmission of power at 2200 volts. Proper protection is attained when using electricity at the above voltage, by the use of metallic armored cables placed in intake airways, and supported by a steel messenger wire. A cable crossing a track is taken underneath it in a conduit or concrete duct. Branch line taps are safeguarded with the usual protected oil switches.

The maintaining of a satisfactory d-c. voltage at the working face becomes more important each year. A 200-kw. portable rotary converter with its necessary accessories has been profitably used to attain such results. The transformers, switchboard, and control panels are mounted on trucks with the same gage as the mine tracks. A special frame structure is bolted to the converter making it possible to attach a truck to it. A movement of the entire station is contemplated every six months. Experience has shown that a complete move requires a period of eight hours.

An improved electric cap lamp consisting of a two-filament gas filled bulb and a bakelite head piece has been placed on the market. The new bulb produces more light, and the head piece, being an insulator, reduces the possibility of accident when worn in the vicinity of electrical conductors. When the main filament burns out, the auxiliary filament may be turned on, thereby enabling the miner to complete his day's work or come out of the mine. As the intensity of illumination in the mines is increased, greater safety may be expected, and no doubt an improvement in the efficiency of labor will follow.

Comprehensive dispatching systems are being placed in operation, their success depending upon a more general use of telephonic and automatic signal systems. In large mines, a system of this type is necessary to get the highest operating efficiency from the haulage system. Telephones are used to distribute the cars, and a signal system moves the trains over the main haulage roads. These systems relieve the mine foremen of considerable detail work, and give them more time for other important mine management problems.

The haulage costs in mines with a large output are being reduced by the introduction of larger mine cars and heavier locomotives. Main line locomotives equipped with three axles and weighing 35 tons are now being used in mines where two-axle locomotives were too small for economical operation. Locomotives of this type have an electropneumatic control, air brakes, and dynamic braking for handling loads on down grades.

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*APPLICATIONS TO MINING WORK:

W. H. Lesser, Chairman.

F. N. Bosson,	A. B. Kiser,	W. F. Schwedes,
Graham Bright,	Carl Lee,	E. D. Stewart,
M. M. Fowler,	John A. Malady,	F. L. Stone,
E. J. Gealy,	C. H. Matthews,	W. A. Thomas,
L. C. Ilsley,	F. C. Nicholson,	E. B. Wagner,
G. M. Kennedy,	H. F. Pigg,	J. F. Wiggert,
R. L. Kingsland,	L. L. Quigley,	C. D. Woodward.
	Herbert S. Sands,	

Presented at the Summer Convention of the A. I. E. E., Denver, Colo., June 25-29, 1928.

An increase in the motor capacity of large locomotives is being obtained by the use of forced ventilation, which is produced by a separate motor-driven blower mounted on the locomotive. The ventilation of the motors has been found to double their continuous rating. Notwithstanding the additional equipment necessary for ventilating the motors, the results obtained are so satisfactory that it has been adopted as standard practise by some manufacturers building three motor locomotives weighing 25 to 35 tons.

The largest mine locomotive ever built has been recently placed in service. It weighs 38 tons, has a 36-in. gage, and semi-elliptic leaf type springs with a three point equalization. Three 133-hp., 500-volt d-c. motors with forced ventilation will furnish the power. A semi-magnetic control arranged for series parallel operation of the motors in either direction constitutes the control equipment. The drawbar pull on level track at 33⅓ per cent adhesion will be 23,333 lb. at a speed of 7.4 mi. per hour.

Mechanical loading has concentrated and increased the service required from gathering locomotives to such an extent that heavier and slower speed locomotives are proving to be the best type. A reduction in the speed of gathering locomotives to 3½ mi. per hour makes it possible to do the same work with a consumption of 30 to 40 per cent less power.

The transportation of coal long distances by belt conveyors instead of locomotives is making progress. Mines in which the coal travels from the face to the tipple on conveyors are possibilities.

The world's largest electrically operated shovel will go into operation during this year in the open-pit mines of Illinois. It is equipped with a 15-cu. yd. dipper, and a boom 120 ft. long. Two 450-hp. motors will provide the power for hoisting, and two 150-hp. motors will do the swinging. A Ward Leonard control will be used, involving a motor generator set, the synchronous motor of which will have a capacity of 1700-kv-a. Shovels of this size will reduce the unit cost of the material handled, and make it possible to increase the ratio of overburden to coal in strip mining.

Where gaseous mines are being supplied with electrical power from large public utility plants over long transmission lines, installations are being made which will make it possible to operate the fans, and to hoist the men during periods when the normal supply of power has failed. An installation of this type consists of two fans, and a man hoist driven by a-c. motors, three-phase, 60 cycles, and 2200 volts. When an interruption of the power occurs, the above equipment is supplied with power at 40 cycles, and 1500 volts. Under these conditions, the control apparatus will function properly, and the motors will operate at two-thirds speed, which is sufficient to keep the mine clear from gas and to hoist the men. The emergency power is produced by a gasoline-engine-driven, 200-kv-a. generator capable of being started by a push-button in case of a power interruption.

A notable electrification program of a large copper mining company has just been completed. The complete electrification of its 28 mines with a connected motor load of about 65,000 hp. shows that electrical power is an important factor in the copper industry. Engineers have overcome many difficulties in the installation and maintenance of electrical apparatus in copper mines, where the action of copper sulphate is so harmful.

In another open-pit copper property, there are 23 electrically-operated shovels in service. This year the entire steam haulage system consisting of 52 steam locomotives will be replaced by 37 trolley locomotives each weighing 75 tons.

In hard rock ore mines, as distinguished from coal mines and other soft ore mines, experiments are being conducted on the electrical equipment required by loaders, slushers, and other machinery. Much progress is being made in the adaptation of motors to this exceptionally severe service.

Automatic controls for mine substations, fans, pumping plants, and air compressors are being continually developed and placed in operation. At the present time there are about 200 automatic pumping stations in operation in the anthracite coal field, representing an annual saving in labor cost of approximately \$500,000. The automatic stopping and starting of air compressors has been developed and several are in successful operation.

A rather unique application of electricity in the mining industry consists in using it for heating the bathing water for those employees who work on holidays or during periods when most of the regular force is idle. In one instance, a steam plant is necessary to heat the water for the normal force of 600 men, while during idle days, immersion heating units in a tank provide sufficient hot water for the reduced force of 25 men.

It is becoming more noticeable each year that the managers of the mines are giving more attention to the maintenance and care of the electrical equipment, resulting in a decreased maintenance cost and a better operating efficiency. The mine electrician in charge of the electrical equipment is given more authority and is directed by the electrical engineer in all technical questions. Frequent inspections of the mine by the engineer and the electrician, together with a good operating organization materially reduce the number of equipment failures, so disastrous to good production.

Average production per man in blast furnaces in the United States increased from 25 tons in 1850 to 1257 tons in 1925, according to the Department of Labor, based upon a study of the subject.

The increase has been almost continuous except for the years immediately affected by war conditions. During the period from 1850 to 1925 the number of employees in the blast furnace industry increased only 44 per cent, while the output increased more than 7000 per cent.

Research

ANNUAL REPORT OF THE COMMITTEE ON RESEARCH*

To the Board of Directors:

1. The Research Committee

In order to increase the activities and usefulness of the committee it seemed desirable to appoint working subcommittees to take charge of the several important divisions of the work. The following have been appointed:

Subcommittee on Placing of Research Subjects with Suitable Persons and Organizations—(D. W. Roper, Chairman).

Subcommittee on Training of Research Men—(V. Bush, Chairman).

The membership of the committee should be so chosen that a considerable percentage of the membership of the subcommittees will overlap from year to year. The appointment of several other working subcommittees is under consideration. It is hoped that the working committees of the Research Committee will eventually make it as effective in the research field as similar working committees have made the Standards Committee in the standardization field. It is suggested that consideration be give to changing the Research Committee from a technical committee to a standing committee.

2. Examples of Outstanding Research During the Year

The spectacular contribution to the communication art in the past year has been television. This has a particular interest from the standpoint of research since it was made possible by improvements in mechanical and electrical facilities that have sprung directly from research work, instances of which are improvements in photoelectric cells, in methods of amplification, in gaseous discharge lamps for producing visible effects from rapidly changing electrical signals, and improved methods of synchronization of widely separated points.

Other developments are the Knowles tube and its application to the televox, starting electrical equipment at a distance, and the development of a 50 million-cycle tube with a 10-kw. output. The increase in power of many American and foreign radio stations, making them international in their effects, raised the question as to whether or not the national standards of radio frequency of various governments were in agreement. During the past year a check was made by Dr. Dellinger of the Bureau of Standards in the National Laboratories of England, France, Italy, and Germany by means of the temperature controlled piezo-oscillator. The average difference was only 0.03 kilocycles in 1000. This is much smaller than the variation of 0.5 kilocycles allowed broadcasting stations in this country.

A radio beacon system establishing an invisible but infallible course along which aviators can fly regardless of weather conditions, has been sufficiently perfected by the Bureau of Standards so that routine use of it on regular airways is beginning.

A most impressive and historic event took place at the Winter Convention this year. Through the courtesy of the American Telephone and Telegraph Company and the British Post Office a joint meeting took place over the radio telephone between the Institution of Electrical Engineers of Great Britain meeting in London and the American Institute of Electrical Engineers meeting in New York.

There has been a number of researches during the past year of a fundamental nature. Particular mention might be made of the work of Davison and Germer regarding the diffraction of electrons by crystals of nickel. They prove that electrons behave at reflection as though they had wavelengths dependent upon their velocity. The discovery and measurement by J. B. Johnson of an electromotive force due to the thermal agitation within conducting materials is also of importance.

Among new tools which increase the scope of fundamental work in physics and engineering might be mentioned the operation by Coolidge of three cathode ray tubes in series at 900,000 volts.

A lightning generator producing impulses of over 3,500,000 volts also offers an important tool for the extension of fundamental work in physics and engineering.

Considerable important work on insulation measurements and lightning measurements on transmission lines is being carried out.

An analysis of the important fundamental research of the country shows that a fairly large percentage is still being done by the large industrial laboratories such as those of the American Telephone and Telegraph, the Westinghouse, and the General Electric Companies.

3. Research Organizations

While the large manufacturing companies are still doing a considerable percentage of the important fundamental research, there are indications that our colleges and other organizations will play an increasingly

*COMMITTEE ON RESEARCH:

F. W. Peck, Jr., Chairman.

H. D. Arnold,	W. P. Dobson,	E. W. Rice, Jr.,
Edward Bennett,	V. Karapetoff,	D. W. Roper,
V. Bush,	A. E. Kennelly,	C. H. Sharp,
E. H. Colpitts,	S. M. Kintner,	C. E. Skinner,
W. F. Davidson,	M. G. Lloyd,	R. W. Sorensen,
W. A. Del Mar	C. E. Magnusson,	J. B. Whitehead.

Presented at the Summer Convention of the A. I. E. E., Denver, Colo., June 25-29, 1928.

important part, as they should. It is reassuring that funds are more readily available than ever before.

An important new factor in research has been given us in the Bartol Foundation, the result of a large bequest. Dr. Swann, director of this organization, which will undoubtedly have a very important influence on future American research, has kindly supplied the following information regarding it.

"The Bartol Research Foundation of the Franklin Institute is at present located in three houses at 127 No. 19 St., Philadelphia. These houses were made over a few years ago for laboratory purposes, and comprise ten research rooms, a library, glass blowing room, shop, and accommodations for storage battery equipment, etc.

The present site is only temporary, pending the completion of a new laboratory. By an arrangement with Swarthmore College, it has been decided to build upon the campus of the college. By this arrangement the laboratory secures a site free from the disturbances of traffic and protected as regards its surroundings. It secures a congenial academic atmosphere such as most of its members have been accustomed to. On the other hand, while there is no affiliation to the college itself, the college feels that our presence will rebound to its advantage in many ways, and we hope and feel that this will be so.

The laboratory will be about 110 ft. long and 50 ft. wide, comprising a basement, first and second floor, and a subbasement large enough to accommodate one spectroscopic room. The attic will also accommodate two rooms. The basement floor includes a large machine shop, wood shop, a glass blowing shop, and a battery installation, together with a room for miscellaneous technical operations.

The first floor will be devoted to research laboratories and a workshop for the fellows, and the director's laboratory and offices. On the second floor there will be an apparatus room, a lecture room and large library, an optical shop, small office and research rooms, and the attic will provide for a chemical laboratory. The whole is designed to accommodate about ten or fifteen fellows together with the director, and research assistants. At the present time the technical staff comprises one instrument maker, one mechanic and an apprentice, also a full time glass blower and a general utility man.

The main activities of the laboratory will be directed to the investigation of scientific problems pertaining to the fundamentals of electrical science. This is, of course, rather a wide field and comprises practically the whole field of modern atomic structure under its head.

While the laboratory is primarily for research, it is proposed to provide in it such conditions for continued mental development as are desirable for young men of the post Ph. D. type. The director and the individual fellows take turns in lecturing to the group upon various phases of modern physics, particularly in relation to atomic structure. The Bartol Foundation has been fortunate in having many lecturers from American institutions, and a fund has been appropriated for the purpose of bringing from time to time distinguished physicists to stay here for a period of two or three months and give the laboratory the benefit of their intellectual contact.

At the present time, the laboratory is accommodating six fellows on its payroll, one National Research Council fellow, a guest fellow, and one research assistant. It is possible that two or more National Research Council fellows will be here next year. Since October 1, 1927, eight publications of the Bartol Foundation have appeared in the *Journal of the Franklin Institute* and six publications of the results of investigations at the laboratory have been presented before the American Physical Society.

The following investigations are at present under way at the laboratory.

1. An investigation on the reflection of atoms of atomic hydrogen from crystal surfaces.
2. The production of, and characteristic properties of X-rays produced by protons.
3. An attempt to detect a magnetic field resulting from the rapid rotation of a copper sphere.
4. An investigation concerning the pulling of electrons out of metal under intense electric fields.
5. An investigation of the loss of velocity of electrons as a result of the production of characteristic X-rays in the passage of the electrons through thin metallic films.
6. A series of investigations pertaining to the mechanisms involved in the production of the electric arc between carbon electrodes and metal electrodes.
7. The design of an apparatus for the production of high electrical potentials.
8. A series of investigations having to do with the effect of high-frequency fields on optical and allied properties of transparent media.
9. An investigation of the nature of excitation of various lines in the mercury arc.
10. An investigation of the part played by cosmic radiation in the production of radio activity.
11. An investigation on the electrical conductivity of non-aqueous solutions of solvents.
12. A theoretical investigation on the scattering of X-rays by matter.
13. The preparation of a paper involving the results of observations of the cosmic radiation, made at Pike's Peak and New Haven."

* * * * *

The Public Utilities are entering the research field and are not only supplying money to colleges, but are also operating research laboratories. As an example, the Utilities Research Commission, made up of representatives of the utilities of which Mr. Samuel Insull is the head, has arranged for investigation of cable insulation at the University of Illinois, of lightning protection at Purdue, and of properties of insulation at the University of Chicago, etc.

Important work is being carried on in insulation by

committees of the National Research Council, the N. E. L. A., etc.

The Research Committee of the Institute serves as the Advisory Committee on Electrical Engineering to the National Research Council and is also closely cooperating with the Engineering Foundation.

4. The Training of Research Workers

Results in research depend more upon men than money and laboratories. It is still a fact that in spite of organized research and group working in large laboratories, outstanding results are generally due to the genius or inspiration of the right man. While such men cannot be manufactured in our colleges, natural ability can be developed under the proper influence. Apparently the colleges are making progress, as indicated by the report of Professor V. Bush, Chairman of the Subcommittee on Training of Research Engineers, which follows:

"There is a considerable increase in the emphasis being placed on graduate study and hence on engineering research, which is an important part of such study, in schools of advanced standing among the technical educational institutions of the country. The total graduate enrolment in engineering colleges on the basis of the statistics of the United States Bureau of Education was 1114 in 1925-26, 1566 in 1926-27, and 1669 in 1927-28. The principal branches are civil, mechanical, electrical, and chemical engineering and in 1925-26 these four included 807 out of the 1114. During the three years cited the figures for civil engineering are 156, 240, and 266; those for mechanical engineering 256, 206, and 240; and those for electrical engineering, 281, 434, and 468. Of course these figures include many graduate students in technical schools where there is little important research being carried on; and perhaps only 30 or 40 per cent are in contact with research of a high order in their institutions. Still it is evident that there is an increasing tendency toward work of this nature in technical schools, and that this tendency is particularly marked in recent years among students of electrical engineering.

It is believed that this tendency toward graduate study and research is a healthy development, and that its growth should be encouraged by industry and by the profession. Perhaps the greatest encouragement that can be given is for the students to learn that real achievement in advanced work is highly regarded by the profession wherever such is the case. There is no doubt that the recent analysis by the Bell System of the correlation between high grades in college and success in later work on their staff, as presented by President W. S. Gifford in Harper's Magazine for May 1928, will have a real vital influence in encouraging a scholarly attitude on the part of undergraduates generally. Similarly, if the industry and profession find by experience that graduate study of a serious sort is worth while for students of outstanding ability, the knowledge that such a conviction exists will be of the greatest value in raising the tone of graduate study and research in the engineering colleges. It is to be hoped, therefore, that the membership of the Institute will watch this development of graduate study and research with interest, and that, if they believe it is a desirable thing for the progress of electrical engineering, they will make known their convictions in an effective manner.

Direct aid of such work by industries is, of course, valuable, particularly when the research carried on at educational institutions is carefully correlated with the regular instruction so that the full pedogogical benefit of working in a research atmosphere is obtained. Some years ago, for example, when graduate study in engineering schools was just beginning to grow, the American Telephone and Telegraph Company contributed directly to electrical engineering research at the Massachusetts Institute of Technology, and the work resulting was conducted in close liaison with the instructional program of that institution. The research results obtained were themselves worth while, but more important was, undoubtedly, the influence upon the student body and the early exposure of students to the research point of view.

It is becoming increasingly evident in recent years that electrical engineering is adopting and applying more and more of mathematical and applied physics and chemistry. Hand in hand with this adoption must go the training of research workers of high calibre who have the engineering attitude, if the greatest progress is to be made. Industrial research is being well carried on by the industry, but the principal supply of research workers must come from the colleges; and, as electrical engineering becomes more and more complex, the training in advanced study and research in the technical schools must continue to expand as it has done in recent years to meet the need."

F. W. Peek, *Chairman.*

LEGISLATION PROBABLE TO CONSERVE OIL

The Federal Oil Conservation Board may recommend to Congress, when it reconvenes in December, legislation providing for the practical conservation of the natural petroleum resources of the country, in line partly with the recommendations of the Committee of Nine to the Board, made after an exhaustive survey, the Acting Secretary of the Interior, E. C. Finney, announced June 4.

Declaring that the Board, consisting of the Secretaries of the Interior, Commerce, War and Navy, was "likely to submit such a bill," Mr. Finney explained however, that there was considerable research work yet to be done. The major part of this work is in respect to the more efficient utilization of natural gas in the withdrawal of the petroleum, so that a larger percentage of extraction may be had through this natural propelling medium, and, in a measure, obviate the present need of using expensive pumping processes for extraction.

Braid Discharge in Single Conductor Cable in Ducts

BY M. J. LOWENBERG[1]

Member, A. I. E. E.

***Synopsis.**—Where single-conductor braided cable is used in conduit, a discharge which may destroy the cable sometimes occurs between the braid and the duct. This can be prevented by the use of a metal covering, or with certain braids. Seine twine braid with weatherproof finish has given trouble in locations where flame-proofed asbestos braid has proved satisfactory. Asbestos braid is superior to cotton braid. The article cites actual experiences encountered, tests made, and remedies used. It is hoped that further thought will be given to this subject and a more satisfactory way found for preventing the trouble.*

THE purpose of this article is to describe the failure of a single-conductor cable from arcs formed between the braid and the duct in which the cable was installed, and some subsequent tests that were made to find an economical method of preventing its recurrence. Single-conductor 750,000-cir. mil cables with 7/16-in. varnished cambric insulation and two weatherproofed cable-laid twine braids were installed in fiber ducts for the leads of a 13,200-volt generator. Shortly after the equipment was put into service one of the leads was destroyed. Examination showed burns for several inches along the cable near the edge of the duct entrance, the burned area being greatest on the outer surface and tapering as it approached the conductor. From inspection of the cable it was quite apparent that the trouble was not due to poor or faulty insulation. The ducts were not wet.

When removed, put on a concrete floor, and tested, this cable evidenced both audible and visible discharge at 4000 volts, increasing to great intensity at 8000 volts, the normal operating voltage to ground. Several theories were then advanced as to the cause of the trouble. One theory was that the braid was damp, causing the charging current to drain off at points where the cable was in contact with the duct, and that these currents were sufficient to burn the braid and insulation. Those who advanced this theory believed that if the braid and duct were dry, no trouble would occur. The second theory was just the reverse. It was based upon the supposition that the phenomena could be likened to two condensers in series, one having varnished cambric as the dielectric, and one having air as the dielectric. Then, if the braid were a perfect insulator, there might be certain air-gaps between the braid and duct subjected to voltages in excess of the dielectric strength of the air. A curve illustrating this is shown in Fig. 1. Those who advanced this theory were of the opinion that if the braid were sufficiently conducting, the points of contact with the duct would reduce the potential across the air-gaps so that no discharge could occur.

Tests were then made on cables having braids of different resistances. A cable having the same size of conductor and thickness of insulation as the one that failed, but using two cotton braids with a flame-proof instead of weatherproof finish, evidenced an audible and

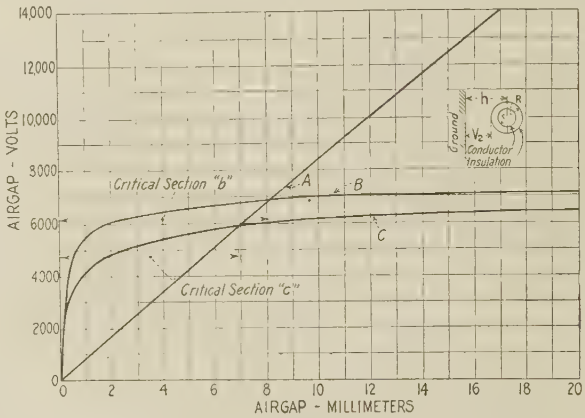

FIG. 1—POTENTIAL STRESS—AIR-GAP CURVE

A A. I. E. E. needle-gap

B Potential stress across air-gap between ground and outside of a 750,000-cir. mil cable with 7/16-in. varnished cambric insulation with constant voltage of 8000 applied between conductor and ground.

C Same as *B* except with 14/16-in. varnished cambric insulation.

B and *C* are plotted in accordance with the following equations:

$$C_1 = \frac{K_1}{2 \log_\epsilon \frac{R}{r}} \tag{1}$$

$$C_2 = \frac{K_2}{2 \log_\epsilon \left(\frac{h + \sqrt{h^2 - R^2}}{R} \right)} \tag{2}$$

and

$$V_2 = \frac{V\, C_1}{C_1 + C_2} \tag{3}$$

where C_1 is capacity per unit length between conductor and outside of cable, C_2, that between outside of cable and ground, V, the potential of conductor to ground, and V_2, that of outside of cable to ground.

K_1 dielectric constant of varnished cambric assumed 4.5

K_2 dielectric constant of air = 1.

visible discharge beginning at about 9500 volts on increasing voltage, and persisting on decreasing voltage to about 8000 volts. Tests at 19 kv. for 18 hr. indicated that any discharge at normal operating range of 13,200 to 14,500 volts was not sufficient to injure the cable. Additional tests, however, were made on the same type of cable, coating the braid with

1. Electrical Engineers, Stone & Webster, Inc., Boston.

aluminum paint and also with graphite. The aluminum coating had a resistance of about 250,000 ohms per ft., the graphite coating about 2 ohms in 6 in., and the original braid about 100,000 megohms per ft. With these coatings, voltages as high as 15,000 volts could be applied before any audible or visible discharge was noted.

The cable with the flame-proof braids and no other painting has been in service for about six years without any trouble, from which it is concluded that cable with flame-proof braid, operating at about 8000 volts to ground, will not be subject to this discharge.

Since the experience related occurred, several other cases have come to the writer's attention where cable with weather-proofed braid in ducts was destroyed due to discharge between the braid and the duct. The writer has been advised that in one installation the remedy adopted was to apply a strip of bronze tape around the insulation. The metal tape fitted tightly to the insulation and prevented discharge between the tape and the insulation. This tape produced little or no sheath current, even when grounded at both ends.

Subsequently tests were made on 1,000,000-cir. mil cable having 12/32-in. varnished cambric insulation. Part of this cable had one tape and a single weather-proofed braid. Discharge began between the braid and ground at about 10,000 volts. At 20,000 volts a pronounced discharge could be seen, which, in all probability, would have eventually destroyed the cable. This discharge appeared to be at an air-gap of about 3/10 of an inch. A second portion of this cable had a tape and a Seine twine braid with flame-proof finish. This portion of the cable had a pronounced discharge at 4000 volts, and at 20,000 volts it discharged on a 7/8-in. air-gap. It was quite apparent that this cable would not be satisfactory for operation above 4000 volts to ground. The third section had a tape and asbestos braid with a flame-proof finish. This section showed a very slight discharge at one thread at 8000 volts and only a very mild discharge at 20,000 volts.

As a result of experience and tests it appears that there is a risk in using in ducts, single-conductor cables with Seine twine weather-proofed braids at a voltage over 4000 volts to ground unless a metal tape is used or the braid made somewhat conducting such as by the use of metallic paint. While no trouble has been experienced with cables having cotton braids with a flame-proof finish, it appears that an asbestos braid with a flame-proof finish is superior. Metal tapes have an advantage over flame-proof or asbestos braids, however, in that the metal tape completely eliminates the corona discharge which while it may not destroy the braided cable, is objectionable due to the formation of ozone.

It may be claimed that the solution of this particular problem is the use of lead sheath or conductors mounted on insulators. While these arrangements may be warranted in many cases, nevertheless there are cases which require cheaper construction if reliability too can thus be obtained. Today it seems quite possible to obtain cables with reliable insulation without resorting to the use of lead with the accompanying difficulties of sheath currents and the risk due to potheads. It is also often difficult to find space to install potheads at generator terminals. It is not claimed that the flame-proofed asbestos braid is a complete solution, as there are cases where the weather-proofed braid is desirable, and it would appear that some method might be developed whereby this braid could be made sufficiently conducting to prevent potential gradients that are destructive.

The writer is indebted to the Simplex Wire and Cable Company for many of the tests made.

MEASURING AND RECORDING CAR JOLTS

Engineers are seeking constantly to design automobiles that will ride more smoothly and comfortably; but so many road and car factors enter into the problem, and different passengers' sense of comfort varies so greatly, that some more accurate means is needed to determine the riding qualities of a car than that of merely riding in it over good, bad, and indifferent roads.

Numerous devices called accelerometers have been developed for the purpose of measuring and recording the jolts and vibrations to which a motor vehicle is subjected. The most recent of these is an electrical instrument developed by R. W. Brown, in charge of the engineering laboratory of the Firestone Tire and Rubber Co. He illustrates and describes it in a recent number of the *S. A. E. Journal.*

Because of its relatively small size and the remote connection with the vibration counter through electric wires, this accelerometer can be mounted on any part of the vehicle so that a record can be made of the vibrations at any place. Thus the action of the tires, axles, springs, body and seats can be studied separately. By using separate accelerometers located in various positions the riding qualities of any individual portion of the vehicle can be segregated, yet all records made at the same time and on the same piece of road. With such records the engineer can proceed to work out the characteristics needed for improvement of each part.

The new instrument contains a series of small weights normally held up against contact points by magnetism from an ironclad solenoid. An upward force breaks the contact and the weights move downward against light springs, which also serve as a lower contact. By means of adjusting screws, each of the weights can be set accurately for a given force or acceleration, and by varying the electric current a wide range of forces can be measured.

The making and breaking of contacts by the weights, caused by vibrations or oscillations of the car, actuates a counter which records the number per second. This

counter must be capable of operating not less than 40 times a second, which means that the total time required for open contacts must not exceed 3/1000ths of a second. It was found that a conventional clock-mechanism escapement could be operated at the necessary speed by means of a small electric current, so six counters of this type were incorporated in a self-contained unit with simple elements for measuring the variation in electrical resistance.

So sensitive is this instrument that variation of as little as five pounds in the air pressure in the tires is made very evident in the records obtained.

ILLUMINATION ITEMS

By Committee on Production and Application of Light

A CORRECTION

In the three preceding issues of the JOURNAL three articles appeared under the head of Illumination Items which were improperly credited to the Committee on Production and Application of Light. The articles were entitled,

"White Light vs. North Skylight for Color Discrimination,"

"Can We Have too Much Daylight?"

"How We Read,"

and were received through the courtesy of the Lighting Research Laboratory at Nela Park to which they should have been credited.

ULTRAVIOLET RADIATION AND HEALTH

Two papers[1] (and several discussions thereof) bearing on ultraviolet radiation in relation to health appear in the March number of the TRANSACTIONS of the Illuminating Engineering Society. A wealth of detailed quantitative data is given on the amount of radiation of different wavelengths present in sunlight (and its variation throughout the year), and in the radiation produced by quartz mercury arcs, carbon arcs etc. The effects of different bands of radiation upon life processes and the transparency to such radiation of different types of light transmitting media also are studied.

Messrs. Hughes and Pycha have found that winter sunshine in Kansas contains about one-eighth as much of the short wavelength radiation which is needed for normal bone development as that of July and August, but that even in winter there is more than twice the amount required to secure the normal development of poultry. They use the bleaching effect of such radiation on an acetone-methylene blue reagent as an index of the amount present.

Doctor Coblentz gives detailed information upon the spectral characteristics of Light Sources and upon the transmission of radiation of short wavelength by various media.

1. A Preliminary Report of the Measurement of Variation of Energy in the "Vita Spectrum" of the Sunshine in Kansas, J. S. Hughes and R. L. Pycha.

Spectral Characteristics of Light Sources and Window Material Used in Therapy, W. W. Coblentz.

In a discussion presenting the physician's point of view, Doctor Herman Goodman gives the results of quantitative experiments he has made in this field.

It appears that ultraviolet radiation in the narrow zone of wavelengths from 290 to 320 mμ. includes all that is of primary importance to life processes.

This radiation is at the very limit of that which reaches the earths surface from the sun. Only 2 per cent of the sun's energy reaching sea level at Washington is in wavelengths shorter than 310 mμ. The intensity of the solar radiation we receive decreases very rapidly as it approaches the limit, 290 mμ., where it is practically negligible. This applies to direct sunlight on clear days. Smoke and dust in the atmosphere greatly reduce the amount of energy received in these short wavelengths, and of course heavy clouds and fogs cut it off completely.

Ultraviolet radiation outside of this narrow band of wavelengths seems to be entirely ineffective from the standpoint of the particular life processes considered.

Both Doctor Coblentz and Doctor Goodman point out that the amount of radiation received from the sun which is of value from the standpoint of health is so very small during the winter months that the question of its transmission by windows is of little importance. Doctor Goodman says, "When the windows must be closed in winter, on cloudy days, or rainy days, the sunlight, even without interposing glasses diminishing its intensity, does not contain enough of the vital rays to produce sunburn, or to protect against rickets." He also remarks that we receive very little direct sunlight through our windows in cities and that reflected sunlight is practically devoid of health-giving "vital" ultraviolet at all times of the year.

Artificial sources producing radiation within the 290- to 320-mμ. zone, such as the mercury and carbon arcs, are therefore important means of securing this so-called "vital" ultraviolet radiation.

FEDERAL POWER COMMISSION NEEDS ADDITIONAL HELP

According to the Executive Secretary of the Federal Power Commission, he is confronted with the task of catching up on an accumulation of work resulting from applications for power licenses that extend over a period of five years, and that it would require at least double the present force to dispose of in another five-year period. Congress is blamed for this condition by its failure to enact legislation to increase the personnel of the commission, thereby leaving it in a deplorable condition.

According to a recent order of the Commission, the issuance of the licenses has been temporarily suspended because of inadequate personnel. There are now only thirty civilian employees and five officers detailed from the Corps of Army Engineers.

Effort was made to secure the additional personnel required in S. 1606 and H. R. 8141, both of which measures were before the last Congress. The latter failed on a record vote in the House of Representatives.

INSTITUTE AND RELATED ACTIVITIES

The Summer Convention at Denver

As we close the forms for this month's issue of the JOURNAL, the Summer Convention of the A. I. E. E. is being held at Denver, Colorado, and from the indications of the first two days of the meeting, a most successful convention may be predicted.

The first day was devoted to conferences of Institute Officers and Section Delegates, held under the auspices of the Committee on Sections and Branches. These conferences occupied the entire day, and in the evening an informal reception was enjoyed.

On Tuesday morning the first order of business was the Annual Meeting, a brief account of which is included in this issue.

The presentation of papers and the reading of the Technical Committee Reports had not commenced as we go to press. A complete report of this Convention will appear in the August issue.

Pacific Coast Convention at Spokane August 28-31

A list of diversified and timely topics is on the technical program of the Pacific Coast Convention to be held in Spokane, Wash., August 28-31.

There will be papers on movement of overhead transmission conductors during short circuits, economical voltages and conductor sizes, transmission-line diagrams, lightning studies, inductive coordination, carrier communication on 200-kv. lines, carrier current on short toll circuits, cable corrosion in wood ducts, heat flow from underground cables, short-circuit currents on loaded systems, automatic substations, crest-voltage measurements, railway electrification, automatic railroad signals, electrolytic refining of zinc, and vacuum-tube applications in the power industry.

Plans for inspection trips and entertainment are being arranged by the Spokane Committee. Further details will be published in the August issue of the JOURNAL. The tentative list of technical papers is as follows:

TENTATIVE LIST OF TECHNICAL PAPERS

The Electrolytic Zinc Plant of the Sullivan Mining Company, by E. R. Fosdick, The Washington Water Power Co.

The Great Northern Railway Electrification, by R. D. Booth and E. L. Moreland, Jackson and Moreland.

Power Supply for Railway Signals and Automatic Train Controls, by C. F. King, Westinghouse Electric & Mfg. Co.

Movements of Overhead Line Conductors during Short Circuits, by Wm. S. Peterson, Los Angeles Bureau of Power & Light, and H. J. McCracken, Jr., Dept. of Water & Power, City of Los Angeles.

Economy in the Choice of Line Voltages and Conductor Sizes for for Transmission Lines, by E. A. Loew, University of Washington.

Generalization of Transmission-Line Diagrams, by H. V. Carpenter, Washington State College.

The Technical Features of Inductive Coordination from the Power Man's Standpoint, by L. J. Corbett, Pacific Gas and Electric Co.

Calculation of Single-Phase and Three-Phase Short-Circuit Currents on Systems under Load, by R. H. Park and E. H. Bancker, General Electric Co.

The Automatic Substation and Its Relation to the Electric Distribution System, by S. J. Lisberger, Pacific Gas and Electric Co.

Calibration of the Point-Gap for Measurement of the Crest Values of 60-Cycle Voltages, by J. S. Carroll, Stanford University.

Heat Flow from Underground Electric Power Cables, by N. P. Bailey, University of Idaho.

Vacuum-Tube Applications in the Light & Power Industry, by L. F. Fuller and W. A. Tolson, General Electric Co.

Some Problems in Power-Line Carrier Telephony and Apparatus Recently Developed to Meet Them, C. F. Boeck and R. D. Gibson, Bell Telephone Laboratories, Inc.

New Light on Lightning Problems from Klydonograph Studies, by A. L. Atherton, Westinghouse Electric & Mfg. Co.

Cable Corrosion in Creosoted Wood Duct, by R. M. Burns, Bell Telephone Laboratories, Inc. and B. A. Freed, Pacific Tel. & Tel. Co.

Carrier Telephone System for Short Toll Circuits, by H. S. Black, Bell Tel. Laboratories, Inc., M. L. Almquist and L. M. Ilgenfritz, A. T. & T. Co.

Atlanta Regional Meeting October 29-31

Plans are progressing for the first Regional Meeting of the Southern District of the Institute, which will be held in Atlanta, Ga., October 29-31.

An interesting technical program covering subjects of particular importance to engineers in the southern part of the country will be presented. Among these will be hydroelectric developments, transmission-voltage control, power-limit and system short-circuit tests, carrier and supervisory control, carrier communication, electrification of the textile industry variable-speed spinning, individual carding and roving, skin effect in dynamo steel, photoelectric and glow-discharge devices, audible light and visible sound, inverted speech and broadcasting problems.

Further information of this meeting will be published in subsequent issues of the JOURNAL.

Illuminating Engineering Society to Meet at Toronto

The Twenty-second Annual Convention of the Illuminating Engineering Society is to be held in Toronto, Ontario, September 17-20, 1928, with headquarters at the King Edward Hotel.

The international side of this convention will be of considerable interest. The first International Illumination Congress, of which this convention is to be a part, is to be held in the United States in September, and will bring together from many countries those interested in lighting.

Papers by foreign authors are listed on the program which is being prepared by the Committee on Papers and which will include unusually varied and worth-while contributions on technical and lighting practise subjects. These papers are so extensive and important that parallel sessions will be necessary.

Full details regarding travel arrangements, program, and hotel reservations will be available later.

National Fuels Meeting to be Held in Cleveland

A cordial invitation has been extended to all members of the Institute to attend the Second National Fuels Meeting, to be held in Cleveland, Ohio, September 17-20, 1928, under the auspices of the Fuels Division of The American Society of Mechanical Engineers. The program for the meeting is being planned to include the whole field of operation in the production and utilization of fuels,—whether coal, oil, or gas,—from mining and preparation to general use. Tentative programs are available and the Committee on General Arrangements requests that anyone

expecting to be present, notify it promptly, addressing A. S. M. E. Fuels Division, Committee on Co-operation with Related Organizations, C. P. Tolman, chairman.

Report of Committee of Tellers on Election of Officers

To the President

American Institute of Electrical Engineers

DEAR SIR:

This Committee has canvaseed the ballots cast for the election of Institute officers for the year 1928-1929, and reports as follows:

Total number of ballot envelopes received		4918
Ballots rejected, in accordance with Art. VI, Secs. 32 and 34 of the Constitution:		
From members in arrears for dues for year ending May 1, 1928	144	
Received in envelope unmarked by identifying signature	57	
Received in improper envelope	91	
Received after May 1, 1928	19	
Blank ballots	35	
		346
Leaving as valid ballots		4572

These 4572 valid ballots were counted, and the result is shown as follows:

FOR PRESIDENT

R. F. Schuchardt	4322
Blank	250

FOR VICE-PRESIDENTS

District		
No. 1.	*North Eastern*	
	E. B. Merriam	4469
	Blank	103
No. 3.	*New York City*	
	H. A. Kidder	4479
	Blank	93
No. 5.	*Great Lakes*	
	W. T. Ryan	4484
	Blank	88
No. 7.	*South West*	
	B. D. Hull	4454
	Blank	118
No. 9.	*North West*	
	G. E. Quinan	4448
	Blank	124

FOR MANAGERS

A. E. Bettis	4502
J. Allen Johnson	4512
A. M. MacCutcheon	4504
Blanks	198

FOR TREASURER

George A. Hamilton	4472
Blank	100

Respectfully submitted

R. R. KIME, *Chairman* — D. B. PERRY
W. E. COOVER — H. O. SIGMUND
J. T. WELLS — E. E. DORTING
W. S. HILL

Committee of Tellers.

Date May 15, 1928

Report of Committee of Tellers on Amendments to the Constitution

To the Board of Directors,

American Institute of Electrical Engineers

GENTLEMEN:

This committee has canvassed the ballots cast on the amendments to the Constitution submitted to the membership in a circular letter dated April 2, 1928, and the result is as follows:

Total number of envelopes received		8425
Of these, the following were rejected in accordance with the Constitution and By-laws for the reasons given below:		
Received from members whose dues were in arrears on June 19, 1928	220	
Received without identifying name on outside of envelope, or because of enclosure in envelopes bearing no indication of contents, etc.	133	
Total invalid ballots		353
Leaving as valid ballots		8072

These valid ballots were counted and the result is as follows:

Subject of Amendment	In favor of	Against	Scattering and Blank
Admission and Transfer of Members	7983	71	18
Dues	7891	161	20
Management—Duties of Officers	7964	88	20
Meetings	7922	124	26
Quorum	7679	369	24
Amendments	7919	129	24
Annual Conventions	7951	95	26
Titles of Officers	7964	82	26

The total membership of the Institute on May 1, 1928 was 18,265. It will therefore be evident from the above that more than 20% of the total membership voted, and that more than 75% of those who voted were in favor of the adoption of each amendment, and, therefore, under the provisions of the Constitution, all the proposed amendments are adopted and go into effect July 26, 1928.

Respectfully submitted,

R. R. KIME, *Chairman* — J. T. WELLS
W. E. COOVER — E. E. DORTING
W. S. HILL — D. B. PERRY
H. O. SIGMUND

Committee of Tellers.

New College of Engineering for University of Southern California

The demand for engineering education and the needs of industries in southern California for centralized and adequately equipped laboratories has led the board of trustees of the University of Southern California to authorize the inauguration of a College of Engineering of which Philip S. Biegler, professor of Electrical Engineering for the past five years has been appointed acting dean. This new college will open September 1928 and will comprise the following five major divisions: Chemical Engineering, Professor Wilfred W. Scott; Civil Engineering, Professor Robert M. Fox; Electrical Engineering, Professor Philip S. Biegler; Mechanical Engineering, Professor Thomas T. Eyre; and Petroleum Engineering, Professor Allen E. Sedgwick. A degree of C. E. has been established also for distinction in the practise of engineering, in addition to the regular four-year courses leading to degrees of B. S. in any division of engineering and a Master's for graduate work.

R. F. Schuchardt

President-Elect of the A. I. E. E.

Mr. R. F. Schuchardt, Electrical Engineer, Commonwealth Edison Company, Chicago, was elected President of the American Institute of Electrical Engineers for the year beginning August 1, 1928 as announced at the Annual Convention of the Institute held in Denver, June 25-29, and in accordance with the report of the Committee of Tellers, which is published on the preceding page.

Rudolph Frederick Schuchardt was born in Milwaukee, Wisconsin, December 14, 1875, and received his early education in private and public schools in that city. He was graduated from the University of Wisconsin with the degree of B. S in Electrical Engineering in June 1897, and was awarded the degree of E. E. in 1911.

R. F. Schuchardt

During the first year after his graduation, he was employed by the Janesville (Wis.) Electric Light and Power Company as general utility man, and later by Meysenburg and Badt, Chicago, as engineering salesman. Since July 1, 1898, he has been with the Chicago Edison Company and its successor, the Commonwealth Edison Company. He was in the testing department from November 1899 to November 1906, passing through all stages from an assistant to the acting head, which position he held for 14 months. In November 1906, Mr. Schuchardt was appointed Engineer of Electrical Construction, and in 1909 he was appointed electrical engineer of the company, which position he still holds.

While acting head of the testing department, he had responsible charge of and personally directed all engineering and acceptance tests on all station and substation equipment installed. In the position which he now holds, he is in charge of all electrical construction in stations and substations, and has done important special work on the complete scheme of system protection.

He is the author of a booklet entitled "Panama and the Isthmian Canal," and a number of technical papers on such subjects as meters, transformer testing, rotary converter substations, and the protection of high voltage transmission systems.

Mr. Schuchardt was elected an Associate of the Institute in 1903, was advanced to the grade of Member in 1909, and to the grade of Fellow in 1912. He was a Vice-President of the Institute for the years 1922-1924. His committee activities in the Institute have been as follows: chairman of Power Generation Committee 1921-22; and member at various times of the Education, Power Generation, Protective Devices, Standards, Power Transmission and Distribution, Meetings and Papers, Executive, Electrical Machinery, and Law Committees. He is still a member of the Law Committee.

His other society memberships include Institution of Electrical Engineers (Great Britain), Western Society of Engineers, Illuminating Engineering Society, National Electric Light Association, Society of American Military Engineers, and American Academy of Political and Social Science.

New York Electrical Society Elects New Officers

At the Annual Business Meeting of the New York Electrical Society held June 12, 1928, in the Engineering Societies Building, 29 West 39th Street, New York, N. Y., the following officers were elected for the administrative year 1928-29: President E. E. Dorting, Lighting Engineer, Interborough Rapid Transit Co.; Vice-Presidents, A. K. Baylor, Executive Dept., General Electric Co.; E. B. Meginniss, Auditor, New York Telephone Co., and H. H. Sheldon, Professor of Physics, Washington Square College, N. Y. U.; Treasurer, E. B. Meginniss; Secretary, H. E. Farrer. The Executive Committee of the Society will also have as members the three Vice-Presidents who hold over for one year: Messrs. R. B. Grove, Secretary, United Elec. Lt. & Pr. Co., H. Pentschler, Director of Research, Westinghouse Lamp Co., and W. T. Teague, Vice-President of the Western Electric Co.,

A World Congress on Illumination

Plans are progressing for a lighting pilgrimage to eastern American cities next September, in connection with the first World Congress on Illumination to be held at Saranac Inn, N. Y., Shortly after the arrival of the delegates in New York, who are expected from many foreign countries, special trains will take them to several important American cities as far west as Chicago.

The visitors will be given an opportunity to inspect all types and varieties of lighting installations in order that they might get the broadest possible understanding of lighting development in America. The tour will be completed at Toronto in time for the opening of the Illuminating Engineering Society convention, September 17th-20th.

G. S. Merrill, of Nela Park, Cleveland, chairman in charge of arrangements for the tour, has reported that a number of American engineers and executives interested in illumination desire to go on the tour. Accordingly, arrangements are being made to take care of as many persons on this side of the ocean as care to make the trip. As plans are still incomplete, Mr. Merrill advises that all interested in knowing about the arrangements should communicate with him, that he may keep them informed and so that he may be able to make ample reservations.

The delegates will be shown every form of lighting practise and impressive receptions are being prepared in many places.

Honorary Members Elected by A. I. E. E.

Five distinguished American engineers were elected Honorary Members of the American Institute of Electrical Engineers at a meeting of its Board of Directors held during the annual Summer Convention of the Institute, at Denver, June 27.

The men thus honored were:

Thomas A. Edison
John J. Carty
Michael I. Pupin
Ambrose Swasey
Elihu Thomson

This was the first time in history that any American Honorary Members have been elected; previously, the Institute had a few foreign Honorary Members, but it was recently decided by the Directors to add to the Honorary Membership List a few outstanding American engineers, and the above five having been nominated in each case by a petition of ten or more members of the Institute, they were elected by the unanimous vote of the twenty-five members of the Board of Directors located in various parts of the United States and Canada, this unanimous vote being one of the requirements of the Constitution in order to effect the election of an Honorary Member.

Brief biographical sketches follow:

Thomas A. Edison, known throughout the world for his achievements was born at Milan, Ohio, in 1847. His first affiliation with the electrical field was as a telegraph operator, to which art he contributed the automatic repeater, quadruplex, and printing telegraphs. He is the father of the incandescent lamp. His numerous inventions have included the carbon telephone transmitter, megaphone, and phonograph. During the World War, Edison served as President of the Naval Consulting Board.

John J. Carty, telephone pioneer and inventor; leader in the development of telephone communication, has been continually associated with the telephone industry since 1879. He was formerly Chief Engineer and is now a Vice-President of the American Telephone and Telegraph Company. During the War, Carty rendered notable service in assembling from telephone personnel, twelve battalions of Signal Corps Troops, and was promoted to the rank of Brigadier General in recognition of his work in France during and after the War. He was President of the American Institute of Electrical Engineers during 1915-16 and Edison Medalist of 1917.

Doctor Michael I. Pupin, Professor of Electro-Mechanics at Columbia University, noted author, lecturer, scientist and inventor, was born at 1858 in Idvor, Serbia. Doctor Pupin's study of electrical wave transmission over long conductors, eventually leading to the development of the Pupin coil in 1901 and making voice transmission over long cables successful, is his best known accomplishment. In addition to many other honors, he is an Edison Medalist. He was President of the American Institute of Electrical Engineers in 1925-26.

Ambrose Swasey, famous manufacturer of precision instruments and mechanisms, was born in 1846. During the World War, Mr. Swasey's firm solved many problems arising in the use of optical instruments, including those necessary for modern fire control of guns. He is an Honorary Member of the British Institutions of both Mechanical and Mining Engineers, as well as of the society of civil engineers of France, and is a Past-President and Honorary Member of The American Society of Mechanical Engineers. Mr. Swasey has contributed half a million dollars to Engineering Foundation for advancement of engineering research.

Elihu Thomson was born 1853 at Manchester, England. He invented and designed the Thomson-Houston arc-lighting system, and was a founder of the Thomson-Houston Company. Since 1891, while with the General Electric Company, he has developed the resistance welding art, and has done much original work in optical construction, photography, special chemical problems, steam turbine and internal combustion engines. He is an Honorary Member of the Institution of Electrical Engineers of Great Britain and 1889-90 was President of the American Institute of Electrical Engineers. In 1909 he was awarded the first Edison Medal.

F. L. Hutchinson,
National Secretary.

Annual Meeting, Denver, June 26, 1928

The Annual Business Meeting of the Institute was held at the Cosmopolitan Hotel, Denver, on Tuesday morning, June 26, 1928, during the annual Summer Convention, President Bancroft Gherardi presiding. An address of welcome was made by Honorable B. F. Stapleton, Mayor of Denver.

The Annual Report of the Board of Directors was presented in abstract by National Secretary F. L. Hutchinson. Printed copies were distributed to members in attendance and are available to any member upon application to Institute Headquarters, New York. The report, which constitutes a résumé of the activities of the Institute during the fiscal year ending April 30, 1928, showed a total membership on that date of 18,265. In addition to the three National conventions and four Regional meetings, 1346 meetings were held by local organizations of the Institute in the principal cities and educational institutions in the United States and Canada. The report will be published in full in the Institute Transactions.

The report of the Committee of Tellers on the election of officers of the Institute was presented, and in accordance therewith, President Gherardi declared the election of the following officers, whose terms will begin on August 1, 1928:

President: R. F. Schuchardt, Electrical Engineer, Commonwealth Edison Co., Chicago, Ill.

Vice-Presidents: E. B. Merriam, Engineer, Switchboard Dept., General Elec. Co., Schenectady, N. Y.

H. A. Kidder, Sup't. of Motive Power, Interborough Rapid Transit Co., New York, N. Y.

W. T. Ryan, Professor, Electrical Power Engineering, University of Minnesota, Minneapolis, Minn.

B. D. Hull, Engineer, Southwestern Bell Telephone Co., Dallas, Tex.

G. E. Quinan, Chief Electrical Engineer, Puget Sound Power & Light Co., Seattle, Wash.

MANAGERS: A. E. Bettis, Vice-President, Kansas City Power & Light Co., Kansas City. Mo.
J. Allen Johnson, Electrical Engineer, Niagara Falls Power Co., Niagara Falls, N. Y.
A. M. MacCutcheon, Engineering Vice-President, Reliance Elec. & Engineering Co., Cleveland, Ohio.

NATIONAL TREASURER: George A. Hamilton, Elizabeth, N. J. (re-elected)

These officers, together with the following hold-over officers, will constitute the Board of Directors for the next administrative year, beginning August 1: Bancroft Gherardi (retiring President), New York City; C. C. Chesney, Pittsfield, Mass.; O. J. Ferguson, Lincoln, Neb.; E. R. Northmore, Los Angeles, Calif.; J. L. Beaver, Bethlehem, Pa.; A. B. Cooper, Toronto, Ont.; C. O. Bickelhaupt, Atlanta, Ga.; M. M. Fowler, Chicago, Ill.; E. C. Stone, Pittsburgh, Pa.; I. E. Moultrop, Boston, Mass.; H. C. Don Carlos, Toronto, Ont.; F. J. Chesterman, Pittsburgh, Pa.; F. C. Hanker, East Pittsburgh, Pa.; E. B. Meyer, Newark, N. J.; H. P. Liversidge, Philadelphia, Pa.

President-elect Schuchardt was called upon and responded with a brief address which was enthusiastically received.

The report of the Tellers upon the ballots cast on the proposed constitutional amendments as submitted to the membership for letter ballot, under date of April 2, 1928, was presented, and showed an overwhelming vote in favor of the adoption of each of the proposed amendments, all of which were thereupon declared adopted, and they will go into effect on July 26, 1928.

The report of the Committee on Award of Institute Prizes as published in full elsewhere in this issue, was read, and the prizes were presented by President Gherardi.

The annual presidential address was then delivered by President Gherardi, the subject being "Civilization and the Engineer." This will be published in a future issue of the JOURNAL.

The Annual Business Meeting then adjourned and was followed immediately by the first Technical Session of the annual Summer Convention.

I. E. C. Advisory Committee Meets at the Hague

Word has been received that the meeting of the Steam Turbine Advisory Committee of the International Electrotechnical Commission, held at The Hague, Holland, during the week of May 20 was a most successful one, and truly international in character, eight nations being represented by 23 distinguished delegates.

This Committee of the I. E. C. is attempting to reconcile the various test codes for steam turbines now used throughout the world and to develop a standard code for international adoption.

The United States was represented at the meeting by I. E. Moultrop, chief engineer and assistant superintendent, Construction Bureau, Edison Electric Illuminating Co., Boston; and Francis Hodgkinson, consulting mechanical engineer, Westinghouse Electric and Manufacturing Co., both members of the Institute; C. B. LePage, Assistant Secretary, A. S. M. E., also attended the meeting as Assistant Director of the Secretariat to the Advisory Committee.

A New Research Fund for High-Voltage Cable Insulation

A research fund of $7500 per year has been placed in the School of Engineering of the Johns Hopkins University by the Utilities Research Commission of Illinois, for an investigation of the properties of impregnated paper as used in the insulation of high-voltage cables. The work will be under the direction of Doctor J. B. Whitehead, Professor of Electrical Engineering. Doctor Whitehead is Chairman of the Committee on Electrical Insulation of the National Research Council, and the work referred to is part of the coordinated plan which is being proposed by that Committee.

Other similar investigations at Johns Hopkins, under Dr. Whitehead's direction, are the Influence of Air and Moisture in Impregnated Paper, supported by the National Electric Light Association; and Dielectric Absorption, supported by the Engineering Foundation, with the cooperation of various electrical industries.

Institute Members Honored by Syracuse Technology Club

At its annual election of officers on May 14, 1928, The Technology Club of Syracuse and Affiliated Societies, one of the first and most successful affiliations of technical societies in this country, elected Rich D. Whitney, president, W. R. McCann, second vice president, and F. E. Verdin a director for three years.

Mr. Whitney is a Fellow of the Institute and a past chairman of the Syracuse Section; Mr. McCann, also a Fellow, is the newly elected chairman of the Syracuse Section, while Mr. Verdin, an Associate, is secretary of the Section.

The Technology Club is to celebrate the twenty-fifth anniversary of its founding this fall and has attained a membership of over one thousand.

A One Year Course in Fuel Engineering

The Towne Scientific School of the University of Pennsylvania makes announcement of a special course in fuel engineering to be given under prominent national authorities on the subject and leading to a degree of Master of Science in Fuel Engineering. The course will open October 1, 1928. In the absence of Professor Robert H. Fernald, Director of the course, absent on leave for the University year 1928-29, Professor William H. Kavanaugh, Professor of Experimental Engineering will be acting director.

It will embrace (A) Fuel resources; (B) Mining methods,—preparation for market, distribution, storage and rehandling; (C) Composition and combustion of fuels; (D) Manufacture of special fuels; (E) Uses of fuels and specifications for purchase; (F) Furnaces; (G) Fuel sampling, analysis and calorimetry; (H) Fuel testing in heating and power appliances; (I) Domestic heating, cooking, and smoke elimination; (J) Regulations affecting use of water power and fuel resources; (K) Research, and (L) Electives.

Application for enrollment or any request for other general information should be addressed to The Dean, Towne Scientific School, University of Pennsylvania, Philadelphia, Pa.

A. E. S. C. Year Book Shows Strides in Standardization

Important standardization activities in many American industries during the past twelve months are described in the Year Book of the American Engineering Standards Committee just off the press. Forty-nine new standards and forty new projects are listed for numerous branches of industry and engineering, including mechanical, civil, electrical, mining, wood, textiles and safety.

Summarizing the benefits of standardization to industry, James A. Farrell, president of the United States Steel Corporation and chairman of the A. E. S. C. Advisory Committee of Industrial Executives said, in part, that "the 300 national organizations and 2000 individuals engaged in the Committee's activities prove that widely divergent interests can meet on a common ground, and the results constitute one of the most notable examples we have of the movement for self-government in industry."

The A. E. S. C. has adopted 111 national standards and is now working on 164 other standardization projects, according to the Year Book, including the following departments of activity: Preferred Numbers; Safety Codes, Unification of Engineering Symbols; Electrical Standards; Mechanical Standards; Automotive; Mining; Wood Industry and Miscellaneous.

Book Reviews

SAFETY AND PRODUCTION. A report by American Engineering Council. Harper & Brothers, New York, 1928, 414 pp. 267 charts and tables; 6 by 9½ in., cloth. $5.00.

This report comprises the first comprehensive study of the relation between production cost and industrial safety. The study covers 60 product groups in 20 basic industries and records the experience of 14,000 American plants with 2,500,000 workers. The United States pays its industrial workers higher wages than are paid in other countries and at the same time is meeting foreign competition in world markets. This result is due to high efficiency in production. It is shown that accidents lessen production and impair efficiency. The book throws an entirely new light on the importance and value of safety work and clearly answers the question; does safety pay?

The committee finds that industrial accidents can be controlled under modern conditions of high productivity; that the experience of a large group of companies shows that material reductions can be obtained in accident rates simultaneously with an increase in production rate, and that the cost of industrial accidents is a loss which should not be neglected. It finds also that organized safety work is being carried on in a relatively small percentage of industrial plants. The committee concludes that safety makes for low production cost and that a responsibility which cannot be evaded rests with managers and executives of industry to make safety a major interest. The book contains a wealth of data and statistics on production and accidents in a wide field of American industries.

THE A-C. COMMUTATOR MOTOR. By C. W. Oliver. D. Van Nostrand Company, New York, 1927. 281 pp., 185 illustrations, 6¼ by 10 in. cloth. $7.50.

This book is divided into two distinct parts, the first being an analytical treatment of various types of a-c. motors, and the second part a non-mathematical description of the principal applications of the commutator motor. The induction motor which has been popular on account of its simplicity and sturdiness is essentially a constant-speed machine and where speed control is required, the solution has generally been the selection of d-c. motors and conversion apparatus. The author believes that the use of a-c. commutators motors, either alone or in combination with induction motors,is a better and more efficient solution of the adjustable speed problem, and claims that the apparent lack of interest in a-c. commutator motor shown in European practise is largely due to misunderstnading of and prejudice against commutation. The lack of interest in commutator motors is ascribed by the author to the dearth of recent comprehensive literature on this subject and the book is written with a view to supplying such information. The inclusion of both analytical and descriptive treatments makes it of interest to a wide variety of readers.

PROBABILITY AND ITS ENGINEERING USES. By Thornton C. Fry. D. Van Nostrand Company, New York, 1928. 476 pp., 49 diagrams, 6¼ by 9¼ in., cloth. $7.50.

The mathematical theory of probability has been recognized for many years principally in its application to life insurance, and it has also been applied to various solutions in pure and applied science. Its use in various engineering problems is becoming more generally recognized, especially in the field of telephony where it has been applied to the solution of numerous practical problems for more than a quarter of a century.

The present book is the outcome of a course of instruction in the Bell Telephone Laboratories which was subsequently revised for use in a course of lectures delivered at the Electrical Engineering department of the Massachusetts Institute of Technology. The work has thus had the advantage of being tried out under actual classroom conditions. The treatment of the subject is very complete, the earlier chapters being devoted to the development of the fundamental mathematics, and the later ones to the application of the principles to numerous kinds of engineering problems. A number of problems for the student to solve is given at the close of each chapter together with numerous bibliographical references. The book is broad enough to cover calculations in all fields of science and industry.

The American Year Book

The 1927 issue of The American Year Book has been announced by the publishers, Doubleday, Doran & Co., Inc., Garden City, N. Y. This volume, edited by Dr. Albert Bushnell Hart of Harvard University, with the cooperation of a Supervisory Board representing 45 national societies and including the A. I. E. E., contains a general survey of the progress made in the nation during the year 1927, supplied by 185 contributors and arranged in 27 divisions. The book contains about 800 pages, one division being entitled "Engineering and Construction."

PERSONAL MENTION

R. S. BRAVO, formerly head of the Mexican Army Signal Corps, is now in charge of the Wireless System in the Republic of Guatemala.

JOHN D. BALL, vice-president of the School of Engineering of Milwaukee and a Fellow of the Institute, has just been given the degree of Doctor of Philosophy by Marquette University.

J. M. BRYANT has resigned from the position of Professor of Electrical Engineering at the University of Texas to accept appointment as Professor of Electrical Engineering and Head of the Department at the University of Minnesota.

DR. J. B. WHITEHEAD, Professor of Electrical Engineering and Dean of the School of Engineering, The Johns Hopkins University, has been made a member of the Advisory Commission appointed by the Mayor of Baltimore to consider the proposal of the Pennsylvania Railroad Company to construct new tunnels and tracks and to equip for electric operation its entrance into, and its terminals within the City of Baltimore.

OBITUARY

John C. Hatzel, President of Hatzel & Buehler, Inc., electrical engineers and contractors, New York City, died at his home on Riverside Drive, May 25, 1928. Mr. Hatzel was a pioneer in the electrical world, having spent most of the sixty-nine years of his life in the profession, and in the early days of electrical development was associated with Thomas A. Edison. His own company was organized in 1884 and for the past forty-four years he has been engaged continuously in the electrical industry. He was often called "the dean of electrical contractors." Mr. Hatzel was a member of the Engineers' Club and former president of the Alumni Association of the Nautical School and the Electrical Contractors' Association. He also belonged to the Newport Yacht Club, the Masons and the Electrochemical Society. He became an Associate of the Institute in 1889 and was transferred to the grade of Member in 1912.

Griffith O. Hughes, Francis R. Howe and **Harley S. Berry**, three members of the Institute and workers in its Los Angeles Section, lost their lives at the time of the St. Francis Dam disaster. Mr. Hughes was in charge of San Francisquito

Power Plant No. 2 located a short distance below the dam and the entire camp and its occupants were lost with the exception of three people. Both Mr. Howe and Mr. Berry were operators at Power House No. 2, Saugus, California.

Fred A. Jones, consulting and construction engineer, Dallas, Texas, and a member of the Institute since 1902 died at his home, 3902 Mockingbird Lane, May 22, 1928.

Mr. Jones was a native of Dallas, and there received his early education. In June 1894 he was graduated from Richmond College Richmond, Va., with an A. B. degree, after which until the fall of 1895 he engaged in commercial interests in Bonham, Texas. He then entered Cornell University and was graduated in 1898 with degree in Mechanical Engineering (Electrical). His thesis was on Steam Turbines with 700 hours spent in actual original research work. The period from January 1899 to January 1901 was spent in varying intervals in the Testing Department of the General Electric Company and its Railway Engineering Department, whence Mr. Jones was sent out to analyze street railway systems and to take charge of experimental railway motor testing; also to calculate the proper equipment for railway systems from data sheets sent in by managers of railway companies. It was after this experience that Mr. Jones became consulting engineer in erection, his first work being the Electric Light and Power Station and Street Railway at Corsica, Texas for the Corsicana Gas and Electric Company. The Southern Pacific Terminal Company at Galvaston employed him on its million-bushel terminal elevator and conveyers for handling freight on docks. Some of the tallest buildings in every leading city in the Southwest are the products of Mr. Jones' engineering ability, including topographical surveys of over 30,000 acres and the erection of power plants for their irrigation. For more than a year prior to his death he had been ill but only for the last seven weeks was he forced to absent his office in Dallas, first opened in 1906. Mr. Jones was transferred to Member's grade in the Institute in 1905, three years after he joined it as an Associate.

John Henry Cuntz, who has been a member of the Institute ever since 1889 and for many years a much respected consulting engineer at Hoboken, died at his home of pneumonia May 29, 1928, in the sixty-second year of his age, Mr. Cuntz was a veteran of the Spanish-American war and World War, as well as being prominent in the fields of engineering and exploration. He was a graduate of Rensselaer Polytechnic Institute in Civil Engineering, and from Stevens Institute of Technology in mechanical and electrical engineering. He spent some time in the Edison Laboratory and also with the Coast and Geodetic Survey in New York Harbor. He was also much interested in political economy and wrote a number of treatises on the gold standard. During his college days he was devoted to all outdoor sports, particularly to mountain climbing; this led to his selection as the scientific member of the Parker expedition up Mt. McKinley in 1910. He was an active member of the Explorers Club, past-chairman of the Alpine Club's New York branch and the Canadian-Alpine Club. At the time of his death he was on the Board of Trustees of the Hoboken Academy and had previously been president of the Alumni Association of Stevens Institute. Mr. Cuntz was an active member of the Institute, and his sudden death is deeply mourned by all who had the privilege of a personal acquaintance with him.

Addresses Wanted

A list of members whose mail has been returned by the postal authorities is given below, together with the addresses as they now appear on the Institute records. Any member knowing the present address of any of these is requested to communicate with the Secretary at 33 West 39th St., New York.

Simpson Carno, 8732 20th Ave., Brooklyn, N. Y.
Leonard L. Dawson, 15 W. Glenaven Ave., Youngstown, Ohio.
L. De Zamacona, 980 Bush St., San Francisco, Calif.
Solomon Harper, 809 E. Fayette St., Syracuse, N. Y.
Albert Holroyd, 928 6th Ave., Astoria, N. Y.
W. B. Kramer, 5745 Center Ave., Pittsburgh, Pa.
Ward W. Lusk, 669 Chetwood St., Oakland, Calif.
Douglas E. Mathewson, 147 Pierpont St., Brooklyn, N. Y.
William J. Norris, 566 Crescent St., Brooklyn, N. Y.
Fred W. Toetz, 465 E. 43rd St., Los Angeles, Calif.

All members are urged to notify Institute Headquarters promptly of any change in mailing or business address, thus obviating needless annoyance and insuring prompt delivery of all Institute mail through the accuracy of mailing records; also eliminating unnecessary expense for postage and clerical work.

A. I. E. E. Section Activities

SECTION ORGANIZED AT DALLAS, TEXAS

At its meeting held on May 18, 1928, the formation of a Section at Dallas, Texas, was authorized by the Board of Directors. The organization meeting of the Section was held on June 2. George A. Mills and A. Chetham-Strode, who had previously been designated temporary Chairman and Secretary, respectively, were elected to those offices for the year beginning August 1, 1928. The other members of the Executive Committee are B. D. Hull; J. B. Thomas, Chairman, Meetings and Papers Committee; T. C. Ruhling, Chairman, Membership Committee; L. T. Blaisdell, Chairman, Entertainment Committee. Marked interest in Institute activities was shown at the meeting.

PAST SECTION MEETINGS

Akron

A Trip Through an Electrical Home, by Mrs. Edna D. Holloway, Home Economist, Northern Ohio Power and Light Co. Annual Meeting. May 25. Attendance 40.

Atlanta

The Mechanical Man, by R. J. Wensley, Westinghouse Electric & Mfg. Co. Meeting was preceded by a dinner. Joint with A. S. M. E. May 11. Attendance 400.

Boston

Annual Meeting. Election of officers. May 16. Attendance 170.

Cleveland

The History of Long-Distance Telephony, by Bancroft Gherardi National President, A. I. E. E. Election of officers. May 24. Attendance 181.

Columbus

Dr. Steinmetz and Heaviside, by Dr. E. S. Berg, Union College. A dinner preceded the meeting. Election of officers. Joint meeting with Ohio State University Branch, A. I. E. E., and Graduate School of Ohio State University. April 27. Attendance 135.

Dallas

Organization Meeting. June 2. (See report elsewhere in this Section Activities department).

Denver

Display of High-Tension and High-Frequency Currents, by H. T. Plumb, General Electric Co. Joint meeting with Denver Chamber of Commerce. May 28. Attendance 3500.

Annual All-Day Meeting. Talk by Col. W. T. Chevalier, McGraw-Hill Publishing Co. Election of officers. May 29. Attendance 900.

Erie

Limitations of Electrical Measuring Equipment, by B. W. St. Clair, General Electric Co. Election of Officers. May 15. Attendance 70.

Fort Wayne

The Scientific Spirit, by Dr. Stanley Coulter, Purdue University. Annual Banquet. May 24. Attendance 88.

Kansas City

Modern Tendencies in Engineering Education, by Dean G. C. Shaad, University of Kansas. Election of officers. May 28. Attendance 45.

Lehigh Valley

Application of Communication Facilities to Control of Electricity, by R. J. Wensley, Westinghouse Electric & Mfg. Co., and

New Developments in the Application of Communication, by B. B. Finley, Bell Telephone Laboratories, Inc. April 21. Attendance 340.

Household Electrical Engineering, by G. W. Alder, Consulting Engineer, Good Housekeeping Institute. Annual Meeting, preceded by a dinner. Election of officers. May 16. Attendance 308.

Los Angeles

The Einstein Theory Analyzed, by R. E. Smith, Southern California Edison Co., and

Electrical and Industrial Advancement in Russia, by Dr. E. W. Kay. Illustrated with slides. Twentieth Anniversary Meeting, preceded by a dinner. June 5. Attendance 132.

Lynn

The Throwing Power of Chromic-Acid Plating Baths, by F. H. Smyser, General Electric Co.

Dry Rectification, by E. H. Harty, General Electric Co., (presented by F. N. Winckler), and

Electric Arc Welding, by P. P. Alexander, General Electric Co. May 23. Attendance 27.

Niagara Falls, by W. F. Dawson, Chairman, Lynn Section. Annual Meeting. Election of officers. June 6. Attendance 47.

Madison

Power Transients in A-C. Motors, by L. E. A. Kelso and G. F. Tracy, University of Wisconsin. Election of officers. May 25. Attendance 20.

Mexico

Railroad Electrification, by John B. Cox, General Electric Co. Illustrated with motion pictures. May 15. Attendance 28.

Milwaukee

Television, by Dr. R. W. King, Bell Telephone Laboratories, Inc. Joint meeting with Engineering Society of Milwaukee. May 16. Attendance 300.

Minnesota

Application of Electricity to Railway Operation, by W. D. Bearce, General Electric Co. Joint meeting with University of Minnesota Branch. May 9. Attendance 55.

Dinner-Dance. May 16. Attendance 60.

Motor-Vehicle Headlighting, by E. W. Johnson, University of Minnesota, and Supervisor of the Minnesota State Motor Vehicle Light Testing Laboratory. Election of officers. May 28. Attendance 22.

Oklahoma

Joint meeting with University of Oklahoma and Oklahoma A. & M. College Branches. (See report in Student Activities department of this issue.) May 19. Attendance 55.

Philadelphia

Mercury Arc Rectifiers, by O. K. Marti, American Brown Boveri Corp. May 14. Attendance 102.

Pittsburgh

Household Electrical Engineering, by G. W. Alder, Consulting Engineer, Good Housekeeping Institute, and Miss Karen Fladoes, Home Service Director, Duquesne Light Co. May 8. Attendance 490.

Portland

Annual Dinner Meeting with Oregon State College Branch, A. I. E. E. May 25. Attendance 72. (See report in Student Activities department of this issue.)

Rochester

Construction and Operation of Electrical Instruments, by A. F. Corby, Jr., Weston Electrical Instrument Corp. Joint meeting with Rochester Engineering Society, preceded by a dinner. Election of officers. May 4. Attendance 78.

St. Louis

Some Notes on Auto Transformers, by Prof. A. S. Langsdorf, Washington University. May 16. Attendance 44.

San Francisco

Manufacture and Application of X-Ray Apparatus, by E. W. Philleo, Victor X-Ray Corp. Illustrated by slides and moving pictures. May 25. Attendance 65.

Seattle

Luminosity of the Nebulae and Temperature of the Stars, by Dr. Herman Zanstra, University of Washington. Annual Meeting. Election of officers. May 15. Attendance 46.

Spokane

Business Meeting. Election of officers. May 25. Attendance 22.

Springfield

Electrical Methods of Recording and Reproducing Sound, by F. J. Fox, American Bosch Magneto Corp. September 19. Attendance 32.

Reminiscences of Heaviside and Steinmetz—Their Personalities and Work, by Dr. E. J. Berg, Union University. Ladies Night. March 27. Attendance 200.

Aviation, a New Life for the Nation, by Hon. John H. Trumbull, Governor of Connecticut. Illustrated with motion pictures. April 24. Attendance 300.

Toledo

Railroad Signals, by H. L. Killian, Signal Supervisor, N. Y. C. R. R. May 25. Attendance 32.

Utah

Joint meeting with University of Utah Branch, A. I. E. E. May 29. Attendance 50. (See report in Student Activities department of this issue.)

Worcester

Radio Interference from the Power System, by J. A. Vahey, Edison Electric & Illuminating Co. of Boston. May 25. Attendance 45.

A. I. E. E. Student Activities

TWENTY-FIFTH ANNIVERSARY MEETING OF PHILADELPHIA SECTION

The Twenty-Fifth Anniversary Meeting of the Philadelphia Section was held at the Engineers' Club on the evening of June 11, 1928, and was preceded by a dinner, also at the Club.

The following program was presented:

Opening Remarks, I. Melville Stein, Chairman Philadelphia Section. Chairman Stein also read a letter from Professor Charles F. Scott, and a telegram from Dr. W. B. Kouwenhoven.

Annual Report, R. H. Silbert, Secretary Philadelphia Section.

Report of Tellers Committee, William Small, Chairman.

Remarks on "Twenty-Fifth Anniversary of Philadelphia Section," Bancroft Gherardi, President A. I. E. E.

The Origin of Sections, H. H. Henline, Assistant National Secretary.

Remarks, J. L. Beaver, Vice-President, Middle Eastern District, A. I. E. E.

At the request of Chairman Stein, Professor Beaver presided during the remainder of the program.

Origin of the Philadelphia Section, H. F. Sanville, Past Chairman.

The Years Between 1884-1903, Clayton W. Pike, Past Chairman.

A New Idea for Sections, Mark R. Woodward, Chairman Lehigh Valley Section.

Remarks, H. P. Charlesworth, Chairman Meetings and Papers Committee, A. I. E. E.

The principal address of the evening was given by Bancroft Gherardi, President of the Institute and Vice-President of the American Telephone and Telegraph Co., upon the subject "The Extension of Long-Distance Telephone Communication". After the completion of the address and the showing of motion pictures on Transatlantic Telephony, President Gherardi answered numerous questions.

Fifteen past-chairmen of the Philadelphia Section were present.

STUDENT BRANCHES ORGANIZED AT DETROIT AND LOUISVILLE

The establishment of a Student Branch at the University of Louisville was authorized by the Board of Directors on April 6, 1928. The following officers have been elected: Chairman, Samuel Evans; Vice-Chairman, Edward Davis; Secretary-Treasurer, Joseph Overstreet.

The Branch at the University of Detroit was authorized on May 18, 1928. The following officers will serve until the spring of 1929: Chairman, Emil T. Faur; Vice-Chairman, Vincent M. Westrick; Secretary, Wm. F. Haldeman; Treasurer, M. J. Alfonso.

The organizing of these two Branches brings the total number to 98.

JOINT SECTION AND BRANCH MEETING IN PORTLAND' OREGON

The annual dinner meeting of the Portland Sections of the Institute and the N. E. L. A. with the Oregon State College Branch was held in Portland on May 25, 1928.

J. E. Yates, Chairman of the Portland Section, A. I. E. E., presided during the first part of the program. H. H. Schoolfield, Vice-President Pacific District A. I. E. E., gave a talk on the student activities of the Institute, including the department in the JOURNAL devoted to such activities, conventions, and joint Section and Branch meetings. He then announced the award of the Branch Paper Prize for the Pacific District (No. 9) for 1927 to F. D. Crowther and R. L. Earnheart for their paper entitled *Alternating-Current Transients in Incandescent Lamps*. In the absence of the authors, who were students at the Oregon State College at the time their paper was presented (May 7, 1927), Professor F. O. McMillan received the certificates and checks.

J. D. Hertz, Chairman, Oregon State College Branch, presided during the presentation of the following papers by students:

The Assembly of an Artificial Line, R. A. Peterson and D. M. Platt.

A New Flexible Curve for Drawing Graphs, N. E. Klein.

The Voltage Ratio Characteristics of Audio Frequency Transformers as Determined by the Low Voltage Cathode Ray Oscillograph, Paul Klev, Jr., and D. W. Shirley.

The Phycho-Galvanic Reflex, M. J. Gross and Paul Klev, Jr. A study of the influence of emotion and fatigue upon the electrical resistance of the human body.

The Electrical Characteristics of Neon Signs, A. A. Lundstrom, E. B. Torvik, and M. D. Pillars.

A Universal Neon Electric Stroboscope, R. Setterstrom and David Don.

The papers were of excellent quality and very interesting to those present. The attendance was about 80.

STUDENT PROGRAM AT UTAH SECTION MEETING

At the annual joint meeting of the Utah Section and University of Utah Branch held on May 29, 1928, the following program was presented by students:

A New Electric Flowmeter, Robert L. Fuller.

University of Utah Experimental Hydroelectric Power Plant, D. K. Brake.

Klydonograph Experiments, Junior Petterson, Secretary University of Utah Branch.

Boulder Dams, J. B. Hunter.

Automatically- Vs. Manually-Controlled Plants, C. E. White, Chairman, University of Utah Branch.

Some Experiments on a Fynn-Weichsel Motor as a Generator, O. K. Stagers.

Modern Magnetic Materials, Davis Bartholomew.

The attendance was about 50.

JOINT SECTION AND BRANCH MEETING IN OKLAHOMA

The Oklahoma Section and the Student Branches at the University of Oklahoma and Oklahoma A. & M. College held a joint meeting at the University of Oklahoma on May 19, 1928. During a morning and an afternoon session, the following papers were presented by seniors of the two schools:

Piezoelectric Oscillators, Le Roy Moffett, University.

A Study of the Audio Frequency Characteristics of a 500-Watt Broadcast Transmitter, Byron McDermott, University.

Wind-Electric Power in Oklahoma, Charles Wyatt and Ford Cole, A. & M. College.

Underground Substation and Conduit Temperatures, J. C. Glaze and W. L. Metcalfe, University.

Report on Experimental Farm Line at Pauls Valley, George E. Larason and Henry Kozel; A. & M. College.

Some Laboratory Methods of Studying Transmission Line Surges, J. S. Harmon and J. B. Hewitt, University.

Stimulation of Egg Production by Use of Electric Light, Tom Blackketter and Franklin Diehnel, A. & M. College.

Transient Performance of Instrument Transformers, Elgin Shaw and G. E. Kaiser, University.

Soil Temperatures in Oklahoma, Sam Davis, A. & M. College.

Certain Types of Receiving Antennas, J. D. Robertson and E. F. Percival, A. & M. College.

The morning session was followed by a luncheon at the Faculty Club and an inspection of the University of Oklahoma campus. The afternoon session was concluded by the election of officers of the Oklahoma Section.

The papers were the results of thesis work done by the students and were presented informally from notes. Attendance was about 55.

EIGHTH ANNUAL BANQUET OF UNIVERSITY OF PITTSBURGH BRANCH

The eighth annual banquet of the University of Pittsburgh Branch was held at the University Club in Pittsburgh on May 17, 1928. The principal address of the evening was given by S. M. Kintner, Manager of the Research Department, Westinghouse Electric & Mfg. Co. A talk on the activities of the Carnegie Institute of Technology Branch was given by G. M. Cooper, chairman of that Branch. Other speakers were Dean Holbrook of the School of Engineering, Professor H. E. Dyche, Head of the Department of Electrical Engineering and Counselor of the Branch, and C. E. Rhem, R. H. Kernahan, K. A. Taylor representing the freshman, sophomore, and junior classes respectively. C. C. Caveny and H. W. Wamhoff spoke for the seniors.

BRANCH MEETINGS

Brooklyn Polytechnic Institute

Business Meeting. The following officers were elected: Chairman, H. F. Steen; Vice-Chairman, R. O. Rippere; Secretary, F. J. Mullen; Treasurer, W. Hutchinson. May 25. Attendance 40.

Bucknell University

What a College Man does in the Telephone Business and Problems Met With and Their Solution, by L. A. Babbitt, Engineer of Transmission and Protection, Bell Telephone Company of Pa. Motion pictures, entitled respectively, "Trans-Oceanic Telephone Service" and "Photo-Telephone Service" were shown. May 9. Attendance 67.

California Institute of Technology

Business Meeting. Nomination of officers. May 8. Attendance 7.

University of California

Inspection of Big Creek Plants of the Southern California Edison Company. May 10-14. Attendance 8.

Carnegie Institute of Technology

Annual Banquet. Talks by members of Faculty, the recently elected Chairman of the University of Pittsburgh Branch, and the Chairman and Guests. Souvenirs, Smokes and Musical Entertainment. The following officers were elected Chairman, G. M. Cooper; Vice-Chairman, M. J. Seibold; Secretary, J. H. Ferrick; Treasurer, O. V. Mitchell. May 9. Attendance 75.

University of Colorado

Development of the Mercury Turbine, by B. B. Coulson, General Electric Co. May 8. Attendance 100.

Annual College Branch Meeting of the Denver Section, A. I. E. E. (For more complete report, see Student Activities, Dept., June JOURNAL.) May 11. Attendance 100.

Meeting held at a fry at a point just outside of Boulder. The following officers were elected for next year: Chairman, H. R. Arnold; Vice-Chairman, W. A. Merriam; Secretary, Eugene Stoekly; Treasurer, R. P. Blackwell. May 31. Attendance 30.

Cooper Union

Motion picture, entitled "The Story of Power," was shown. The President asked members to prepare papers and said the best would be presented at New York Student Convention. January 11. Attendance 40.

Electrolysis, by Frank Congilose, 5th Year Night E. E. student and I. R. T. subway engineer. The Chairman announced the program of the New York Section Student Convention. March 14. Attendance 20.

Human Relations, by R. Chevalier, Engineering News-Record. Joint meeting of the professional and scientific societies of Cooper Union. The Secretary of each organization gave a report on the year's activities and progress. Two-reel motion picture comedy and refreshments. March 31. Attendance 175.

A-C. Networks, by Charles Coles, student. Two-reel moving picture "The Story of an Electric Meter" was shown. April 17. Attendance 25.

University of Denver

Business Meeting. The following officers were elected: Chairman, J. N. Petrie; Vice-Chairman, H. E. Olson; Secretary-Treasurer, Dale Cooper; Corresponding Secretary, Jeith Jacobs. Chairman Baker gave a report of the College Night meeting of the Denver section. Decided to postpone electrical show to May 25. May 18. Attendance 12.

Duke University

Business Meeting. The following officers were elected: Chairman, W. E. Cranford; Vice-Chairman, F. A. Bevacqua; Secretary, Charles Berglund; Treasurer, Bennet Forbes. May 21. Attendance 13.

Georgia School of Technology

Motion picture, entitled "The Principles of Electricity," was shown. Appointment of nominating committee. May 15. Attendance 66.

The Various Types of Lightning Arresters, by Prof. E. S. Hannaford, Counselor. The following officers were elected for next year; Chairman, E. W. Burn; Vice-Chairman, R. D. Trammell; Secretary-Treasurer, K. W. Mowry. May 22. Attendance 42.

Iowa State College

Business Meeting. The following officers were elected: Chairman, R. R. Law; Vice-President, C. D. Martin; Secretary-Treasurer, Carl Rohrig. May 29. Attendance 16.

State University of Iowa

Analysis of Structure of Materials by Means of X-Rays, by R. L. Roy, and

Automatic Motor Starters, by W. W. Wertzbaugher. March 21. Attendance 26.

The Radio Direction Finder, by R. N. Weldy, and

Size and Progress of the Commonwealth Edison Company, by M. J. Maiers, Lecturer, Chicago Central Station Institute. March 28. Attendance 26.

Motion picture, entitled "From Coal to Electricity," was shown. April 4. Attendance 26.

Residential Water Heating, by W. H. Wickham;

Arc Welded Structures and Bridges, by A. Feldt, and

Electric Railways, by N. R. Bector. April 11. Attendance 26.

Electrification of Rural Districts, by J. T. Hicklin;

Interconnecting of Power Developments, by M. H. Jensen, and

Regeneration in Radio Receivers, by J. T. Jones. April 18. Attendance 26.

The Mercury Arc Rectifier vs. the Synchronous Converter, by H. W. Johnston;

The Inverted Vacuum Tube as a Reversing Voltage Amplifier, by D. D. MacDougall, and

Protective Grounding, by L. L. Heskett. April 25. Attendance 26.

Heat Losses in D-C. Armature Conductors, by F. C. Mathis, and

Switching Induction Regulators Into and Out of Service, by B .R. Olsen. May 2. Attendance 26.

Applications of Electricity to Railway Operation, by W. D. Bearce, Railway Engineering Dept., General Electric Co. May 7. Attendance 40.

Power from Pumped Water, by J. L. Jordan, and

Starters for Squirrel-Cage Motors, by G. L. Pruhdon. May 16. Attendance 27.

Kansas State College

Business Meeting. The following officers were elected: President, H. C. Lindberg; Vice-President, M. C. Coffman; Secretary, D. C. Lee; Treasurer, R. K. Whitford; Corresponding Secretary, J. W. Schwanke. May 21. Attendance 47.

University of Louisville

Vacuum Tubes, by Robert Krajnak, student, and

Vacuum Tube Repeaters, by Wilson Talcott, student. May 3. Attendance 10.

The Principles and Construction of Voltmeters, Ammeters and Wattmeters, by Mr. Corby, Weston Electrical Instrument Corp. Several reels of film on meters were shown. May 24. Attendance 25.

University of Michigan

Motion pictures, entitled respectively "Conowingo" and "Making Mazda Lamps," were shown. May 22. Attendance 25.

Mississippi A. & M. College

Annual Banquet. Talks by Professor L. L. Patterson, Head of Electrical Dept.; H. W. Moody, Dean of Engg. School; S. C. Commander, Prof. of Elec. Engg.; E. L. Lucas, Prof. of Mechanical Engg.; Chairman Stainton, Vice-Chairman Robins and T. H. Rogers. The following officers were elected for next year: R. S. Kersh, Vice-Chairman, C. H. Mangum. May 3. Attendance 40.

Missouri School of Mines and Metallurgy

Motion picture, entitled "The Electric Giant," was shown. January 31. Attendance 17.

Montana State College

Accident Prevention, by E. Sears, Division Master Mechanic, C. M. & S. P. R. R. May 10. Attendance 135.

University of Nebraska

The Electrical Engineer as a Business Man, by C. C. Helmers, President, Iowa-Nebraska Power Co. A short talk was

given by each senior on "My Work after Graduation." Refreshments served. May 17. Attendance 28.

Newark College of Engineering

A five-reel film on "Meters" was presented by G. Smith, Weston Electrical Instrument Corp. Decided that final meeting of the year is to be a smoker. May 7. Attendance 22.

First Annual Smoker. Talks by Dean A. R. Cullimore, N. L. Welsh, General Electric Co., and Prof. J. C. Peet, Counselor. Refreshments were served. May 21. Attendance 65.

College of the City of New York

Motion picture, entitled "From Mine to Consumer," was presented by Mr. O'Brien. May 17. Attendance 42.

Business Meeting. The following officers were elected: Chairman, Daniel Klatzko; Vice-Chairman, Q. Galante; Secretary, Walter Broleen; Treasurer, Charles Fedter. May 31. Attendance 16.

North Carolina State College

Business Meeting. Articles for review assigned for next several meetings. May 15. Attendance 18.

University of North Carolina

Cooperative System, University of North Carolina, by J. H. Hines, and

Power Advertising of the Duke Power Company, by W. N. Michael. May 17. Attendance 20.

Ohio Northern University

Business Meeting. The following officers were elected: President, R. Rice; Vice-President, T. Rundell; Secretary, R. Lash; Treasurer, H. Rosebrook. April 12. Attendance 20.

Television, by T. Rundell, and

Two- and Three-Phase Transmission, by R. C. Williams. April 24. Attendance 16.

Hydroelectric Development of the Conowingo Dam, by President Rice. Prof. I. S. Campbell, Counselor, gave an account of the A. I. E. E. Regional Meeting at Baltimore, Md. Program Committee appointed by the President. May 10. Attendance 15.

Ohio State University

Joint meeting with Columbus Section. Informal Get-Together. Students and others related personal experiences. Light luncheon served. May 20. Attendance 35.

Farewell meeting for graduates. Graduating students presented papers describing their thesis work. Prof. F. C. Caldwell, Counselor, was presented with a desk pen as a token of his work for the Branch. June 2.

Heaviside and Steinmetz, by Dr. E. J. Berg, Prof. of Elec. Engg., Union College. A dinner preceded the meeting. April 27. Attendance 50.

Electric Arc Welding, by J. F. Lincoln, General Manager, Lincoln Electric Co. Chairman Spry gave a report on his trip to Baltimore Regional Meeting. May 17. Attendance 55.

Chairman Spry gave a farewell talk to the seniors. Members of the faculty gave messages of advice to those leaving and seniors presented short talks concerning their thesis work. May 31. Attendance 45.

Oregon State College

Joint meeting with Portland Sections of the A. I. E. E. and National Electric Light Association. (See report elsewhere in Student Activities Dept.) May 25. Attendance 85.

Business Meeting. Branch By-laws concerning membership were amended. The following officers elected for next year were installed: President, Harry Loggan; Vice-President, Ralph Mize; Secretary-Treasurer, Artro Swingle; Publicity Manager, Wayne Goodale; Executive Council, Fred Burelbach and Ray Williams. A silver loving cup, given annually to the outstanding sophomore in electrical engineering by Eta Kappa Nu, was presented by F. O. McMillan to Lowell Hollingsworth. Discussion of Pacific Coast Convention. May 31. Attendance 25.

Pennsylvania State College

President Dannerth gave a report on the Annual Conference on Student Activities held at Baltimore. May 9. Attendance 15.

Neon Electric Stroboscope, by C. A. Nickle, General Electric Co. The following officers were elected: Chairman, H. W. Bair; Secretary, J. F. Houldin; Treasurer, R. L. Hallett. May 22. Attendance 45.

University of Pennsylvania

Business Meeting. The following officers were elected: President, T. E. Manning; Vice-President, H. A. Robinson; Secretary, H. Wilbur Brown, Jr.; Treasurer, C. Paul Young. April 16. Attendance 40.

Development of Leaders from the Ranks, by M. L. Cooke, Consulting Engr. Dr. Harold Pender, Dean of the Moore School, described the progress of the School during the past and expressed his views concerning the future development of the School. Moore School Keys awarded to Warren A. Baxter, Alexander L. Pugh, Jr., Cornelius N. Weygandt, B. Fletcher Moore, Jr., Richard S. Palmer and S. Reid Warren, Jr. Fourth Annual Banquet of the Moore School of Electrical Engineering held under auspices of the Branch. May 2. Attendance 46.

University of Pittsburgh

Eighth Annual Banquet of the Branch. (See report elsewhere in Student Activities Dept.) May 17. Attendance 50.

Purdue University

Motion picture, entitled "The Manufacture of Porcelain Insulators," was shown. May 22. Attendance 20.

Rhode Island State College

Business Meeting. A set of by-laws was adopted. The following officers were elected: President, S. W. Nichols; Vice-President, F. E. Caulfield; Secretary-Treasurer, A. Z. Smith. May 4. Attendance 21.

Recent Developments in the Mercury Arc Rectifier, the Mercury Turbine, and Hydroelectricity, by Prof. Wm. Anderson, Counselor. He also outlined the plan of the Rocky River hydroelectric development in Connecticut and the application of mercury arc rectifiers in street railway work in Bridgeport, Conn. T. B. Miner gave a résumé of the activities at the regional meeting at New Haven. May 18. Attendance 20.

Rose Polytechnic Institute

Electrifying the Railways, by W. D. Bearce, Railway Dept., General Electric Co. May 3. Attendance 47.

Business Meeting. The following officers were elected: Chairman, R. H. Dowen; Secretary, G. P. Brosman. May 21. Attendance 41.

Rutgers University

Smoker. The following officers were elected: President, John Cost; Vice-President, Herbert Lehmann; Secretary-Treasurer, Henry Hobson; Recording Secretary, Robert Shepard. May 14. Attendance 20.

University of Southern California

Applications of Carbon Products to Industry, and Characteristics Needed by Engineer Salesmen, by E. A. Williford, Manager, Carbon Sales Div., National Cargon Co. April 24. Attendance 35.

Inspection trip to Long Beach Steam Plant of the Southern California Edison Co. May 18. Attendance 25.

Stanford University

Arrangements made for an inspection trip to the Redwood City Plant of the Pacific Portland Cement Co. C. A. Binns, General Electric Co., spoke on the electrical equipment of that plant. May 10. Attendance 21.

Inspection trip to Redwood City Plant, Pacific Portland Cement Co. May 12. Attendance 23.

Business Meeting. Committee appointed to investigate and order a bulletin board to be presented to the Electrical Engineering Department to be used for notices of Branch activities. Prof. T. H. Morgan, Counselor, given a vote of thanks for his help and cooperation with Branch activities during the past year. The following officers were elected: Chairman, N. R. Morgan; Vice-Chairman, E. F. Orrick; Secretary, W. G. Snyder. May 31. Attendance 17.

Syracuse University

Interconnection of Large Power Systems, by Arthur Helfer, and

Holland Tunnel, by Kenneth Eastwood. February 16. Attendance 10.

Machine Switching Telephony, by Reo Miles. Motion pictures entitled "Television," and "Transatlantic Telephony," were shown. March 1. Attendance 12.

Television, by Armand Belle Isle, and

Prone Method of Resuscitation, by Robert Schwarting. March 8. Attendance 10.

Power Systems of California, by Elliott Lynde and Bernard Loren. March 22. Attendance 10.

Railroad Electrification, by Earl Gilchrist. March 29. Attendance 10.

Salesmanship, by Francis Plank. April 19. Attendance 10.

Relays Used for Power System Protection, by John Walsh. May 3. Attendance 6.

Mercury Arc Rectifiers, by Elliott Lynde. Business Meeting. May 17. Attendance 30.

Texas A. & M. College

Three films on manufacture of large electrical equipment and automatic control of power-line substations were shown. Decided to hold election of officers at end of scholastic year instead of at beginning. The following were elected: Chairman, H. W. Whitney; Secretary, H. L. Wilke. May 18. Attendance 51.

University of Texas

The Value of an A. I. E. E. Branch to the Engineering Student, by Prof. J. A. Correll, Counselor. May 10. Attendance 15.

University of Utah

Joint meeting with the University of Utah Engineering Society. Motion pictures, entitled respectively "The Conquest of the Forest" and "The Panama Canal," were shown. May 11. Attendance 41.

Magnetic Properties of Nickel Alloys, by Davis Bartholomew, student. Program of student papers for joint meeting with Salt Lake City Section was arranged. May 15. Attendance 13.

Business Meeting. Last meeting of year. May 29. Attendance 10.

University of Vermont

Prof. L. P. Dickinson, Counselor, gave a description of the Student Convention at New Haven and reviewed briefly some of the papers that were delivered. Chairman F. L. Sulloway described the Rocky River Project. May 22. Attendance 7.

Virginia Military Institute

Electrical Advertising, by D. Green;

Tomorrow in the Electrical World, by C. Wesson;

Electrical Insulating Oil, by C. R. Rodwell, and

Use of Synchronous Motors in Steel Mill Service, by F. Pugh. Discussion of plans for next year. May 7. Attendance 36.

University of Virginia

Business Meeting. The following officers were elected: Chairman, C. E. McMurdo; Secretary, L. R. Quarles; Treasurer, S. R. Sayers. May 21. Attendance 15.

Washington University

Business Meeting. Final arrangements were made for the Electrical Engineers' Smoker to be held May 17. The following officers were elected: President, H. J. Miller; Vice-President, C. J. Kettler; Secretary-Treasurer, W. L. Knaus. May 10. Attendance 36.

Smoker. W. W. Horner, President of the Engineers' Club gave an address of welcome. Two movies relating to the telephone industry were shown,—"The Voice Across the Sea" and "The Little Big Fellow." Music by E. E. student orchestra. Refreshments served. May 17. Attendance 87.

University of Washington

Transient Photography, by Carl Radin, student. Business session. May 10. Attendance 17.

Baker River Power Project, by Wm. Bolster, Chairman. Nominations announced. May 17. Attendance 13.

Magnatron Tube, by A. L. Krause, student, and

Use of the Oscillograph on Large Power Systems, by J. H. Park, student. The following officers were elected: Chairman, C. W. Huffine; Vice-Chairman, K. M. Durkee; Secretary-Treasurer, R. C. Leithead. May 24. Attendance 16.

Columbia River Basin Project, by C. N. Butt, student. May 31. Attendance 10.

University of Wisconsin

Business Meeting. The following officers were elected for next year. June 1. Attendance 27.

Engineering Societies Library

The Library is a cooperative activity of the American Institute of Electrical Engineers, the American Society of Civil Engineers, the American Institute of Mining and Metallurgical Engineers and the American Society of Mechanical Engineers. It is administered for these Founder Societies by the United Engineering Society, as a public reference library of engineering and the allied sciences. It contains 150,000 volumes and pamphlets and receives currently most of the important periodicals in its field. It is housed in the Engineering Societies Building, 29 West Thirty-ninth St., New York.

In order to place the resources of the Library at the disposal of those unable to visit it in person, the Library is prepared to furnish lists of references to engineering subjects, copies or translations of articles, and similar assistance. Charges sufficient to cover the cost of this work are made.

The Library maintains a collection of modern technical books which may be rented by members residing in North America. A rental of five cents a day, plus transportation, is charged.

The Director of the Library will gladly give information concerning charges for the various kinds of service to those interested. In asking for information, letters should be made as definite as possible, so that the investigator may understand clearly what is desired.

The library is open from 9 a. m. to 10 p. m. on all week days except holidays throughout the year except during July and August when the hours are 9 a. m. to 5 p. m.

BOOK NOTICES MAY 1-31.

Unless otherwise specified, books in this list have been presented by publishers. The Society does not assume responsibility for any statement made; these are taken from the preface or the text of the book.

All books listed may be consulted in the Engineering Societies Library.

The Abrasive Handbook.

By Fred B. Jacobs. Cleveland, Penton Pub. Co., 1928. 547 pp., diagrs., 9 x 6 in., cloth. $5.00.

A reference book on abrasives and grinding practise for the manager, abrasive engineer, superintendent, foreman, grinding machine operator and student. It points out how many classes of work can be ground advantageously and answers most of the questions confronting the users of abrasive materials or grinding machines.

The editor has spent many years gathering data on grinding, and has now published them in this book, the first of its kind.

Besselsche, Kugel-und Elliptische Funktionen. (Verzeichnis berechneter funktionentafeln, erster teil.

By Institut für angewandte Mathematik an der Universität Berlin). Berlin, [V. D. I., Verlag], 1928. 30 pp., tables, 11 x 8 in., paper. 3,50 r. m.

In numerous engineering calculations, especially in the fields of electricity, heat, and the strength of materials, numerical tables are needed which cannot be found in the usual handbooks. Tables of various functions, which have been calculated from time to time for various purposes, are scattered in numerous publications and are not easily located. This pamphlet, prepared at the instigation of the Verein deutscher Ingenieure, gives exact information about all published numerical tables of Bessel, elliptic and conical functions, telling where they may be found, their compass, exactness and reliability. It will often save the labor of recalculation.

Brass Founders' Alloys.

By John F. Buchanan. 2nd ed. London, E. & F. N. Spon, 1928. 233 pp., illus. 7 x 5 in., cloth. 10/6.

The first edition of this book was published at a period when secrecy prevailed in alloying practise. It is now revised to include new methods, new mixtures, and the new standards recently devised by the coordination of effort in the laboratories and in the foundries. The alloys are discussed from the foundry point of view with the object of presenting in condensed form the information that is essential to practical foundrymen and engineers.

Commercial Electrical Measuring Instruments.

By R. M. Archer. London, Sir Isaac Pitman & Sons, 1928. 259 pp., diagrs., 7 x 5 in., cloth. $3.00.

An introductory book on commercial electrical measuring instruments, prepared from lectures by the author to student apprentices employed by electricity works. It is intended to help all those who use instruments but who have neither the time nor inclination to study the more abstruse branches of the subject.

Descriptive Geometry.

By William H. Kirchner and Henry C. T. Eggers. N. Y., McGraw-Hill Book Co., 1928. 183 pp., diagrs., 9 x 6 in., cloth. $2.25.

This text has been prepared for the use of engineering and scientific students, and emphasis has been placed on the fundamental principles. The subject has not been taken up exhaustively, but is briefed so that it can be completed in a semester.

The book makes a feature of the interrelation of descriptive and analytical geometries, and it is assumed that the student has completed or is taking a course in elementary analytical geometry.

Diesel Engine Design.

By H. F. P. Purday. 3rd edition. London, Constable & Co., 1928. 360 pp., illus., diagrs., tables, 9 x 6 in., cloth. 21S.

In this new edition, a number of minor alterations have been made to the text of the second edition, and later references to literature have been added. A chapter has been included dealing with some recent developments in double-acting engines and super-charging. A more complete account is given of the twisting effects in crank-shafts, and the previous treatment of torsional vibrations has been amplified.

Early Mathematical Sciences in North and South America.

By Florian Cajori. Bost., Richard G. Badger, 1928. 156 pp., illus., 8 x 5 in., cloth. $3.00.

A history of the development of mathematics, astronomy, surveying and physics in the western world. Takes up first the Maya symbol for zero which is many centuries older than our Hindu-Arabic notation. Includes meridian measurements of the earth, the 1761 and 1769 transits of Venus, comets, almanacs and orreries.

Electric Heating.

By Edgar A. Wilcox. N. Y., McGraw-Hill Book Co., 1928. 469 pp., illus., tables, 9 x 6 in., cloth. $5.00.

This book is intended to fill the present demand for published data on electric heating. It gives a general perspective of the field, tries to show that electric heating is being given the recognition it deserves, and gives data and descriptive matter for ready reference purposes. It is intended for the use of commercial executives, salesmen, and engineers engaged in creating markets for either heating apparatus or the resultant heating loads.

Considerable space is allotted to the operating characteristics of various heating devices and the kind of load they create. It takes up the merits and limitations of both electric and fuel heat, and the processes to which either may be applied.

Several chapters are devoted to fundamentals, and most of the information in the other chapters has been assembled from engineering society reports, trade journals, government publications and the author's experience.

Elementary Organic Chemistry.

By Homer Adkins and S. M. McElvain. N. Y., McGraw-Hill Book Co., 1928. (International Chemical series) 183 pp., 8 x 6 in., cloth. $2.25.

This book was written in an attempt to facilitate and improve the instruction in a short course in organic chemistry of approximately fifty class room periods of instruction that is given at the University of Wisconsin. It aims to present the subject in a one-semester course, for the thousands of students in colleges each year who desire such a course, for normal and summer school work. It presents a summary of facts such as a student might be expected to note down in a lecture course in organic chemistry, leaving to the individual instructor the vitalization of the subject.

Isolierte Leitungen und Kabel.

By Richard Apt. 3rd edition. Berlin, Julius Springer, 1928. 235 pp., diagrs., tables, 9 x 5 in., paper. 12.-r. m.

A commentary upon the specifications and standards of the Verein deutscher ingenieure on insulated electric wire and cables. The book supplements the necessarily brief text of the official standards by explaining points which might be misunderstood and by setting forth the principles underlying them.

John Stevens, An American Record.

By Archibald Douglas Turnbull. N. Y., The Century Co., 1928. 545 pp., illus., diagrs., 9 x 6 in., cloth. $5.00.

Colonel John Stevens (1749-1838) was the leading American engineer of 1880. He built and operated twin-screw propeller steamboats on the Hudson River three years before Fulton's Clermont. He built the first ocean-going steamer, the first "steam-carriage" even run on rails in America, and the earliest steam-ferry service in the world.

This biography was written from a collection of private letters, essays, drawings, patents, maps, deeds and contemporary newspapers, including letters he received and his answers, and documents and pamphlets he had printed or which were sent to him by his friends.

Kuhlen und Schmieren Bei Der Metallbearbeitung.

By K. Gottwein. 2d edition. Berlin, V. D. I. Verlag, 1928. 93 pp., illus., 9 x 6 in., paper. 6,-r. m.

A concise handbook on the cooling and lubricating of metal-cutting tools, dies, etc., which has enjoyed great popularity in Germany. It discusses the methods of cooling and lubricating tools, the substances used, their properties and the purposes for which they are suitable. Methods of testing are described and the selection of lubricants for various operations is treated. There are chapters on the recovery of oil and the cleaning of the work, and a section giving the results in practise with various lubricants. The book summarizes wide experience in a practical way.

Manufactured Gas. A textbook of America practise.

By Jerome J. Morgan. Vol. 2. N. Y., Jerome J. Morgan, 1928. 447 pp., illus., diagrs., 11 x 8 in., cloth. $7.50.

Vol. 2 takes up the equipment used in distributing gas from the manufacturing plant to the consumer. This equipment includes the storage of gas in high- and low-pressure holders, mains and services, pumping machinery, governors and meters. Then the problem of distribution design is taken up, which is the combination of the equipment into a properly functioning system. This is followed by a discussion of the "new business department" of the gas company, domestic appliances, general industrial applications, gas furnace design, the selection of an industrial fuel, testing and research work, safety and accident prevention.

The last part of the volume is devoted to accounting and statistics, principles of rate making, and public relations.

Laboratory Glass Blowing.

By Fracis C. Frary, C. S. Taylor and J. D. Edwards. 2d edition. N. Y., McGraw-Hill Book Co., 1928. 116 pp., illus., tables, 8 x 6 in., cloth. $1.50.

This book, which emanates from the research laboratory of the Aluminum Company of America, gives detailed, clear directions for the operations needed in making simple laboratory glassware and for ordinary repairs. In addition, methods are given for sealing and joining glass to metal. The book will be useful to physicists and chemists.

Measurement of Air Flow.

By E. Ower. Lond., Chapman Hall, 1927. 199 pp., illus., diagrs., tables, 9 x 6 in., cloth. 15s.

This book is intended to serve as a text-book for students and as a work of reference for engineers engaged on matters that involve the measurement of the speeds and pressures of air streams. It deals in a practical manner with the theory and technique of the measurement of air flow and gives references to literature on methods and instruments for laboratory use only. The author has included material on the design of static tubes and the theory of the vane anemometer.

Modern Gasoline Automobile.

By Victor W. Pagé. 1928 edition. N. Y. Norman W. Henley Pub. Co., 1928. 1148 pp., illus., diagrs., 9 x 6 in., fabrikoid. $5.00.

While a certain portion of the previous edition remains unchanged, much additional matter has been included to keep pace

with the progress of the industry. Supplementary matter has been added on ignition, starting and lighting, and new material has been included on busses and rail cars, gasoline-electric drive, front-wheel and four-wheel drive, and steering systems. At the suggestion of teachers a series of questions for review has been placed at the end of each chapter.

PATENT LAW FOR THE INVENTOR AND EXECUTIVE.

By H. A. Toulmiss, Jr. N. Y. Harper & Bros., 1928. 288 pp., forms, 8 x 5 in., cloth. $4.00.

The purpose of this book is to present the subject of patent law in a manner that may be assimilated readily by the ordinary business man. Parts of it were published as magazine articles. In addition to the material that is ordinarily found in a book on this subject, there are chapters on the ownership of patents, stimulation of invention by employees, having inventions made to order, the value of patents, their inclusion in the income tax return, patent pools, and the use of patents to control resale prices.

PRAKTISCHES HANDBUCH DER GESAMTEN SCHWEISSTECHNIK; v. 1, Gasschmelzschweiss- und Schneidtechnik. 2d edition.

By P. Schimpke and Hans A. Horn. Berlin, Julius Springer, 1928. 222 pp., illus., diagrs., tables, 10 x 7 in., bound. 12.-r. m.

This work aims to give a comprehensive, detailed account of gas welding and cutting practise which will meet the needs of the welder and also be of use to engineers and factory managers. The authors have attempted to include everything of value and to reject non-essentials, and to make the book a practical guide to satisfactory work.

The new edition contains more information on acetylene generators, welding cast iron and non-ferrous metals, testing welds, and costs.

PRINCIPLES OF FACTORY ORGANIZATION AND MANAGEMENT.

By Ralph Currier Davis. N. Y., Harper and Brothers, 1928. 449 pp., illus., charts. 9 x 6 in., cloth. $5.00.

This book is designed to supply students of industrial management, and all executives who desire a complete understanding of factory management with a clear picture of the fundamental principles and functions. It illustrates the more advanced management practises and trends in modern management theory, and uses many charts and pictures to illustrate the points discussed.

PRINCIPLES OF MECHANICAL REFRIGERATION.

By H. J. Macintire. 2d edition. N. Y., McGraw-Hill book co., 1928. 317 pp., illus., diagrs., tables, 8 x 6 in., cloth. $3.00.

A study course for operating engineers. About 100 pages of text have been added to bring the book as nearly up to date as possible. Numerous typical problems have been solved and new tables and diagrams have been included to assist in the solution of these problems.

The author hopes that the book will be sufficiently complete for instruction in refrigeration where only an introduction to the subject is desired and time does not permit a thorough study of the theory involved.

PRINCIPLES OF THERMODYNAMICS.

By George Birtwistle. Cambridge, University Press (N. Y. Macmillan) 1925. 163 pp., diagrs., 9 x 6 in., cloth. $2.75.

This book contains the substance of lectures given in the University of Cambridge in summer courses, the object of which was to give the fundamental principles of the subject and to illustrate them by applications to branches of science where only a general knowledge of the science was required for their appreciation.

RIEMENSCHLUPF UND REIBUNGSZAHL VON GUMMI-UND LEDERTREIBRIEMEN.

By Hans Nowsky. (Versuchsfeld für Maschinenelemente der Technischen Hochschule zu Berlin, heft 8). 56 pp., diagrs., 11 x 8 in., paper. Price not quoted.

The elasticity and slip of two rubber belts and one leather belt were measured and the differences between the two kinds of belts treated. The slip was analyzed with the help of three methods of measurement, the creep separated from the slip and the local slip at any point, determined. The determination of the coefficient of friction during running is connected to these measurements.

SCIENTIFIC PURCHASING.

By Edward T. Gushée and L. F. Boffey. N. Y., McGraw-Hill Book Co., 1928. 196 pp., charts, forms, 9 x 6 in., cloth. $3.00.

This book does not give in detail the routine of a typical purchasing department, but tries to point out the foundation for successful purchase routine. The actual routine should vary with the refinements of a particular concern, and must be given particular study. This book leads up to that study. It is a text book of fair dealing between buyer and seller and is not intended merely for expert purchasing agents, but for all who want their trading to be fair.

SIR ISAAC NEWTON, 1727-1927. A bicentenary evaluation of his work.

Prepared under the auspices of The History of Science Society. Balt., Williams and Wilkins Co., 1928. 351 pp., 9 x 6 in., cloth. $5.00.

This book consists of a series of papers prepared under the auspices of the History of Science Society. The papers take up the work of Newton in optics, gravitation, astrophysics, dynamics, fluxions, alchemistry and chemistry and his work in the mint. Includes an account of the 20 years' delay in announcing the law of gravitation, and his first critical disciple in the American Colonies—John Winthrop.

SNAPSHOTS OF SCIENCE.

By Edwin E. Slosson. N. Y., Century Co., 1928. 299 pp., illus., diagrs., 7 x 5 in., cloth. $2.00.

The numerous aspects of the amazing scientific progress of our day are presented for the general reader. In an interesting manner the book touches upon recent applications of science to industry and agriculture, contributions of chemistry to medicine, novel inventions, strange discoveries, ancient history of the world and the universe, etc.

SYMBOLISCHE METHODE ZUR LOSUNG VON WECHSELSTROMAUFGABEN.

By Hugo Ring. 2nd edition. Berlin, Julius Springer, 1928. 80 pp., 9 x 6 in., paper. 4,50 r. m.

In spite of the many advantages of the method of complex quantities for a-c. calculations, this author feels that it is not as widely used as it should be. This is due, he thinks, to the usual method of presentation, and he has therefore prepared this text to remove the difficulty. It aims to supply a concise, yet comprehensive text-book on the method, in so far as it is useful to the electrical engineer, and illustrates its applications by practical examples.

TEXT-BOOK OF ORGANIC CHEMISTRY.

By Joseph Scudder Chamberlain. Second edition. Phila., P. Blakiston's Son & Co., 1928. 901 pp., 9 x 6 in., cloth. $4.00.

This book is written primarily as a text-book for the undergraduate student and the instructor. Its method and order of treatment are the result of the author's experience in teaching during the last 10 years.

In this second edition, a list of study questions and problems has been added to the end of each chapter. Where necessary, new material has been added to bring the book up to date. Considerable condensation has been effected in the writing of formulas and reactions.

VESTIGES OF PRE-METRIC WEIGHTS AND MEASURES.

By Arthur E. Kennelly. N. Y., Macmillan Company, 1928. 189 pp., 8 x 5 in., cloth. $2.50.

Since 1800, more than 30 European Countries have officially adopted the metric system, and this book is the result of an investigation to find how numerous or important the vestiges of old units might be in commerce and business. It also throws some light on the question of the time it takes for a country adopting the metric system to bring it into general use.

THE NEW QUANTUM MECHANICS.

By George Birtwistle. Cambridge, University press; [N. Y., Macmillan Co.] 1928. 290 pp., diagrs., tables, 9 x 6 in., cloth.

"This book is concerned with the development of quantum mechanics during the past two years. A detailed account is given of the matrix theory of Heisenberg, Born and Jordan, the q-number theory of Dirac, and the wave mechanics of Schrödinger. The earlier chapters are devoted to a restatement of the Landé theory of the multiplets in a form which is in consonance with the new mechanics which is to follow; some later chapters are given up to the de Broglie theory of particles and their waves, and to the new statistics of Bose, Einstein, Permi and Dirac.

The book closes with the resonance theory of the helium spectrum lately given by Heisenberg, and with the new speculations of Bohr on the limitations imposed by the quantum theory upon the possibilities of experimental observation."

Engineering Societies Employment Service

Under joint management of the national societies of Civil, Mining, Mechanical and Electrical Engineers cooperating with the Western Society of Engineers. The service is available only to their membership, and is maintained as a cooperative bureau by contributions from the societies and their individual members who are directly benefited.

Offices:—31 West 39th St., New York, N. Y.,—W. V. Brown, Manager.

1216 Engineering Bldg., 205 W. Wacker Drive, Chicago, Ill., A. K. Krauser, Manager.

57 Post St., San Francisco, Calif., N. D. Cook, Manager.

MEN AVAILABLE.—Brief announcements will be published without charge but will not be repeated except upon requests received after an interval of one month. Names and records will remain in the active files of the bureau for a period of three months and are renewable upon request. Notices for this Department should be addressed to ***EMPLOYMENT SERVICE, 31 WEST 39th Street, New York City,*** *and should be received prior to the 15th day of the month.*

OPPORTUNITIES.—A Bulletin of engineering positions available is published weekly and is available to members of the Societies concerned at a subscription of $3 per quarter, or $10 per annum, payable in advance. Positions not filled promptly as a result of publication in the Bulletin may be announced herein, as formerly.

VOLUNTARY CONTRIBUTIONS.—Members obtaining positions through the medium of this service are invited to cooperate with the Societies in the financing of the work by contributions made within thirty days after placement, on the basis of one and one-half per cent of the first year's salary; temporary positions (of one month or less) three per cent of total salary received. The income contributed by the members, together with the finances appropriated by the four societies named above will it is hoped, be sufficient not only to maintain, but to increase and extend the service.

REPLIES TO ANNOUNCEMENTS.—Replies to announcements published herein or in the Bulletin, should be addressed to the key number indicated in each case, with a two cent stamp attached for reforwarding, and forwarded to the Employment Service as above. Replies received by the bureau after the positions to which they refer have been filled will not be forwarded.

POSITIONS OPEN

ELECTRICAL ENGINEER, young, as physicist with analytical mind and preferably with experience on induction disk motors or watthour motors, research and development group. Apply by letter. Salary $300 a month. Location, East. X-5170.

ELECTRICAL ENGINEER for large utility in Middlewest, with one to four years' experience. Operating, mathematical, research and economic problems on underground cables and studies of lightning on overhead circuits. Apply by letter. X-5194-C.

MEN AVAILABLE

ELECTRICAL ENGINEER, 28, married, Cornell, E. E. Two years public utility overhead and underground distribution design and construction; six months traveling, sales, service and installation; two years assistant chief in 25,000-hp. industrial plant with own power plant, maintenance, construction, operating, test, surveys, and reports. Available on one month's notice. Best of references. C-4559-85-C-5 San Francisco.

STUDENT ENGINEER, 24, single. Electrical engineer, graduate Western University in 1927, now on General Electric Test Course desires permanent employment in West. Location preferred, San Francisco Bay region. C-4558-85-C-6 San Francisco.

ELECTRICAL ENGINEER, 30, married, B. S. '26. Over two years overhead estimating inspection and maintenance. Employed at present large eastern utility; desires connection with public utility, preferably in Colorado or California. C-1629.

EXECUTIVE ENGINEER OR MANAGER, 39, married. Lifetime of general utility experience in above-average responsibilities. Last five years executive, staff 300 in three-quarter million meter property, developing seven million dollars construction annually. Familiar with all types of problems. Prefer industrial connection affording opportunity of later buying interest. C-3963.

GRADUATE ELECTRICAL ENGINEER, 25, single. Two years General Electrical test course. Seven months special automatic equipment work. Available on one month's notice. C-4593.

ELECTRICAL AND MECHANICAL DRAFTSMAN, 28, single, technical graduate with eight years' experience covering design of automotive equipment, fire alarm systems, electric power stations and sales. Desires position with manufacturing, engineering, or public utility. Location preferred. United States. C-4510.

ELECTRICAL ENGINEER, graduated in June from Penn State, desires a position of opportunity in the commercial or lighting field. Location, immaterial. C-4471.

MANUFACTURING EXECUTIVE seeks connection with a future. Graduate in both Mechanical and Electrical Engineering. Eight years' experience on design of small electrical apparatus. Two years as manufacturing engineer of a large department. Six years as production manager of a large plant. Thoroughly experienced in handling labor and controlling modern manufacture. C-4587.

ASSISTANT EXECUTIVE, 36, married. Well balanced experience of 15 years covers costs, commercial statistics, process analyses, administrative control and rate studies. Seven years large company serving subsidiaries. Technical graduate. Able assistant. Prefers administrative or commercial to strictly technical. Location preferred, eastern United States. B-9122.

ELECTRICAL ENGINEER, 34, experienced in industrial maintenance, layout and construction. Eight years wire and cable test and manufacturing experience; same production and motor repair shop training; desires opportunity to prove ability. B-920.

JUNIOR ENGINEER, B. S. in E. E., Canadian University, single, good health, active, ambitious and conscientious. Will strive for success with large manufacturing or traction company. Mathematical grounding; speaks English, German, some French. One year Canadian General Electric Test. Location preferred, Canada, Middle or Western United States. Available August 1. C-4557.

ELECTRICAL ENGINEER with profound theoretical knowledge and more than twenty years' practical experience in research and designing, desired responsible, permanent position. Speaks French and German. Locations preferred, Pittsburgh district or East. C-693.

EXECUTIVE AND SALES ENGINEER, 37, married. Technical training and 12 years' varied experience, sales, purchasing, industrial construction and operation and central station engineering; desires connection in power sales work or with manufacturer. Wide acquaintance in the South, excellent business and social connections. B-1599.

ELECTRICAL ENGINEER, 37, American; B. S. and M. S. in E. E. Twelve years' professional experience, including General Electric test and laboratories, radio, teaching and consulting. Conversant with electric railway, illumination and public utility practise. Desires to work into permanent executive position, not necessarily electrotechnical. Location, immaterial. Available, September. C-4591.

ELECTRICAL ENGINEER, 26, married, M. S., 18 months General Electric test course, familiar with manufacture of moderate size motors, street lighting transformers and apparatus and cable. Competent in research and test supervision. One year with Eastern public utility. Location, St. Louis or vicinity. C-4632.

ELECTRICAL ENGINEER, 1924 graduate, 28, with business and management experience and two years public utility appraisal work. Familiar with electrical contracting and thoroughly acquainted with the radio business. Desires position covering either engineering or business fields, (preferably combining both), of managerial or executive nature, or leading to such. B-9528.

ENGINEER - EXECUTIVE - MANAGER, graduate E. E., married, 14 years' experience, including wide experience in accounting, design, sales, production, electrical porcelain; manager of large plant for national corporation. Broad knowledge of engineering materials. Loyalty, initiative, and record of assuming responsibility is unquestioned. Interested in business and management of electrical specialty. Can organize, manage operations efficiently and economically. C-3679.

TECHNICAL GRADUATE, American born, E. E., desires position with public utility or industrial concern in Middle West. 1½ years construction and maintenance, 1½ years industrial control paper mill, 8 months power plant drafting. C-4428.

ELECTRICAL ENGINEER, Canadian, McGill graduate. Good balance of design, construction, operating engineering on hydroelectric stations, substations. Thorough understanding engineering principles, and their application. Has supervised design, research on various types substations. Six years' experience with American, Canadian organizations, including electrical laboratory, electrical design, inspector, checker, assistant engineer of design; also independent business experience. C-4668.

YOUNG MAN, 24, single, good technical and business training, two years' experience in installation and maintenance of recording gages, flow meters, and controlling apparatus, such as used in steam power plants, and pulp and paper mills. Capable of managing operations efficiently. Location, immaterial. Available on short notice. C-4663.

ELECTRICAL ENGINEER, 31, with manufacturing experience. Especially well trained in

development, manufacture, and application of carbon brushes. C-4652.

ELECTRICAL ENGINEER, 29, four years iron and steel works electrical installation, maintenance; one year central station operation; three years oil fields electrical installation and maintenance; two and one-half years electrical design of central and substations; three years switchgear and switchboard erection. Location, United States or foreign. C-625.

ELEVATOR ENGINEER, 34, graduate E. E., six and a half years of general elevator superintending experience. Desires position where there is chance for advancement. C-4486.

ENGINEER, American; married; broad experience designing, constructing power and industrial plants, substations, distribution and transmission lines. Prepared reports, steam surveys, pulverized fuel layouts and specifications for electric lighting and cables. Thoroughly qualified executive and good business manager. Desires immediate employment; can furnish highest references. Internationally recognized and honored. B-3954.

ELECTRICAL ENGINEER, 26, technical graduate. One year's operating experience; two and one-half years Westinghouse: test, engineering switching equipment, switchboards, manual and automatic, system study, relay, circuit breaker application. Hydroelectric experience public utility. Desires position engineering department public utility; hydroelectric construction, or operating division. Location, New England, New York, Quebec or New Brunswick, Canada. C-4605.

ENGINEER, 30, married, technical graduate in Electrical Engineering; three years' experience with public utility in transmission and distribution department comprising design as well as intimate public relations; also considerable radio engineering experience; desires position affording opportunity of more extensive use of training as well as substantial advancement, dependent upon ability. Location, East. C-1723.

ASSISTANT DISTRIBUTION ENGINEER, 42, single. Electrical and Civil Engineer, technical graduate. Seven years' civil engineering experience. Two years transmission line surveying. Four years distribution engineering, overhead lines, 11,000 volts and under. Rural extensions, city conversion and reconstruction. Speaks Spanish. Available immediately. Spanish America or Middle West preferred. C-2495.

ASSISTANT ELECTRICAL ENGINEER, 28, American, married, graduate. Four years' teaching experience, Rensselaer Polytechnic Institute; four years' experience General Electric Company. Successfully employed by large corporation; desires semi-commercial or publicity opening in utility, manufacturing with greater opportunity for advancement. Considerable mathematical, literary experience; prize winner nation wide radio play competition, station WGY. Location, immaterial. B-7443.

ELECTRICAL ENGINEER, 26, married, holds degrees of A. B., B. S. and E. E. from Columbia University; practical experience in test work and power substation operation, desires position with manufacturing or public utility company looking toward advancement to executive position. Location preferred, East. C-1495.

ELECTRICAL ENGINEER, 30, married, desires work on hydroelectric construction or operation. Experience: two years hydro, one and one-half years steam plant operation; one and one-half years substation construction, four years high head hydroelectric construction. Now chief electrician, hydroelectric construction. Expert switchboard wireman. Location immaterial; Japan or India preferred. C-4482.

ENGINEER, 34, married, M. S. and E. E. Eleven years' experience including teaching; operating department public utility; industrial research and design. Desires position having executive responsibilities with utility or industrial plant, where recognition is based on actual accomplishments. Location immaterial; West preferred. B-7223.

ELECTRICAL ENGINEER, 29, single, Swiss, graduate E. E. of the Politechnical University Zurick, European and American experience in design and layout of power plants and substations. Employed at present; desires new connection with consulting engineer. Speaks English, French and German. Excellent references. C-4254.

ELECTRICAL ENGINEER, graduate in E. E., 15 years' experience; General Electric test, anthracite coal fields, large New York State power company, testing, maintenance, inspection, electrical drafting and construction of power houses, substations and transmission lines. Some steel mill experience. C-4012.

ELECTRICAL ENGINEER, 39, married, of high reputation, experienced in design and cost calculation of electric lighting and industrial installations, desires connection with organization of consulting engineer or architects. Location preferred, New York City. B-8609.

ELECTRICAL ENGINEER, 30, technical graduate, B. S. in E. E., 1921. Three years' experience electric and ice-plant operation, including plant efficiency work. Also six months hydroelectric distribution work covering all phases, as assistant division engineer, large power company. Location, immaterial. C-4629.

UTILITY ENGINEER, 41, married. Wide experience in power and lighting sales management, new business surveys, rates and industrial plant electrification; desires connection with utility, holding company or engineering firm. Ten years with utilities, five years in industrial plants. Thorough technical training in electrical and mechanical engineering. Salary $5000. B-4451.

TECHNICAL GRADUATE, 28, single. One year Westinghouse test floor work. Two years supervising general tests on electrical and mechanical apparatus. Desires engineering position with public utility in Central America or West Indies. Fair knowledge of Spanish. C-2312.

GRADUATE ELECTRICAL ENGINEER, 26, single, German degree, with one and one-half years' experience in laboratory for automatic switches, relays and layouts; one and one-half years in testing electrical equipment, desires position in laboratory and development. Available on two weeks' notice. C-4639.

GRADUATE ENGINEER, 22, single, B. S. in electrical engineering, Brown University, 1928, with good scholastic record. Experienced in varied foundry and machine shop practise. Desires permanent position in a general engineering organization. Willing to work hard; unusual adaptability. Location, immaterial. C-4672.

ELECTRICAL ENGINEER AND SUPERVISOR, 32, broad experience with utilities in both office and field, desires new connection in responsible position such as assistant manager or electrical superintendent; excellent record. Available at short notice. Salary $3600. B-5505.

MEMBERSHIP—Applications, Elections, Transfers, Etc.

RECOMMENDED FOR TRANSFER

The Board of Examiners, at its meeting held June 13, 1928, recommended the following members for transfer to the grade of membership indicated. Any objection to these transfers should be filed at once with the National Secretary.

To Grade of Fellow

BICKELHAUPT, CARROLL O., Vice-President, Southern Bell Tel. & Tel. Co., Atlanta, Ga.

FAUCETT, I. T., Manager Bayonne Plant, Safety Cable Co., Bayonne, N. J.

NORTHMORE, E. R., Supt. Electric Distribution, Los Angeles Gas & Elec. Corp., Los Angeles, Calif.

To Grade of Member

ATTWOOD, STEPHEN S., Asst. Prof. of Elec. Engg., University of Michigan, Ann Arbor, Michigan.

BIRKETT, MILES W., Vice-President and General Manager, Washington Water Power Co., Spokane, Wash.

BOOTH, JESSE J., Asst. Supt., Elec. Dept., National Tube Co., Gary, Indiana.

ELDER, MATTHEW L., Engineer, General Electric Co., Erie, Pa.

FLOYD, GEORGE D., Testing Engineer, Hydro Electric Power Comm., Toronto, Ont., Canada.

FORSTALL, EDWARD LOGAN, Asst. Engr., Bell Telephone Co. of Pa., Pittsburgh, Pa.

HALL, WESLEY B., Asst. Prof. of Elec. Engg., Yale University, New Haven, Conn.

LEWIS, CHARLES H., Distribution Engineer, Public Service Elec. & Gas Co., Newark, N. J.

McCURDY, RALPH G., Engineer, American Tel. & Tel. Co., New York, N. Y.

McHUGH, JOHN A., Asst. Engr., Elec. Engg. Dept., N. Y. Edison Co., New York, N. Y.

MOORE, ETHELBERT E., Asst. Engr., Hydro Electric Power Comm., Toronto, Ont., Can.

PHILBRICK, FREDERICK B., Asst. Chief Engr., The Gamewell Co., Newton Upper Falls, Mass.

POST, ARTHUR W., Telephone Engineer, American Tel. & Tel. Co., New York, N. Y.

PRICE, TYLER G., Junior Engineer, Commonwealth Edison Co., Chicago, Ill.

STICHT, HERMAN H., Manager, Herman H. Sticht & Co., New York, N. Y.

TURNOCK, HARRY C., Chief Elec. Engr., Hatfield Electric Co., Cleveland, Ohio.

WEST, CHARLES P., Section Engineer, Switchboard Engg. Dept., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

APPLICATIONS FOR ELECTION

Applications have been received by the Secretary from the following candidates for election to membership in the Institute. Unless otherwise indicated, the applicant has applied for admission as an Associate. If the applicant has applied for direct admission to a higher grade than Associate, the grade follows immediately after the name. Any member objecting to the election of any of these candidates should so inform the Secretary before July 31, 1928.

Anderson, W. C., Pratt Institute, Brooklyn, N. Y.

Ariagno, O., New York Edison Co., New York, N. Y.

Barton, D. N., Southern California Telephone Co., Los Angeles, Calif.

Benchea, J. T., 3315 Block Ave., East Chicago, Ind.

Beyer, H., Cornell Electric Mfg. Co., Long Island City, N. Y.

Bodine, H. K., Philadelphia Electric Co., Philadelphia, Pa.
(Applicant for re-election.)

Boyer, J. M., (Member), Chesapake & Potomac Telephone Co., Washington. D. C.

Brower, W. M., (Member), Federal Telegraph Co., Palo Alto, Calif.

Coles, A., Jr., Radio Consultant & Experimenter, Brooklyn, N. Y.

Colvin, A. D., Southwestern Bell Telephone Co., Dallas, Texas
Cohn, B. S., Kansas Electric Power Co., Madison, Kans.
Cooper, F. A., Southwestern Bell Telephone Co., Dallas, Texas
Copeland, J. S., Alan T. Cooke & Co., Houston, Texas
Corey, P. S., (Member), Ohio Brass Co., Mansfield, Ohio
Davidson, O. H., O. H. Davidson Co., Denver, Colo.
Devine, L. V., General Electric Co., Cincinnati, Ohio
Dyer, G. A., Southwestern Bell Telephone Co., Dallas, Texas
Eckberg, C. R., Illinois Bell Tel. Co., Chicago, Ill.
Eldridge, C. C., Binghamton Lt. Heat & Power Co., Binghamton, N. Y.
Ferguson, F. A., (Member), Westinghouse Elec. & Mfg. Co., Denver, Colo.
Gowing, M. R., (Member), Ohio Brass Co., Mansfield, Ohio
Greer, C. M., Harrington, Howard & Ash, Kansas City, Mo.
Haus, I. J., Globar Corp., Milwaukee, Wis.
Head, C. F., Westinghouse Elec. & Mfg. Co., Boston, Mass.
*Herson, J. S., Signal Corps, U. S. A., Oceanport, N. J.
Hume, J. N., General Electric Co., Cincinnati, Ohio
James, L. S., Public Service Co. of Colorado, Boulder, Colo.
Jenkins, R. W., D. L. & W. R. R., Hoboken, N. J.
Jones, R. F., Cleveland Electric Illuminating Co., Cleveland, Ohio
Kater, A. C., Houston Armature Works, Houston, Texas
Kennedy, R. M., Southwestern Bell Telephone Co., Dallas, Texas
Lawther, H. P., Jr., Southwestern Bell Telephone Co., Dallas, Texas
Mace, W. A., Montreal Light, Heat & Power Cons., Montreal, Que.
Mathis, J. D., Southwestern Bell Telephone Co., Dallas, Texas
McGee, R. R., General Electric Co., Schenectady, N. Y.
Michal, O. L., Bell Telephone Laboratories, Inc., New York, N. Y.
Mickley, N. E., Chester Valley Electric Co., Coatesville, Pa.
Milburn, J. D., Pacific Elec. Mfg. Corp.; Walter Bates Steel Corp., Dallas, Texas
Page, H. F., American Tel. & Tel. Co., Chicago, Ill.
Paul, C. F., Progress Electric Co., Cleveland, Ohio
Payne, H. C., (Member), Bethlehem Electrical Const. Co., Bethlehem, Pa.
Pence, H. B., Consumers Power Co., Saginaw, Mich.
Porter, L. C., (Member), Edison Lamp Works, Harrison, N. J.
Rathbun, J. M., NePage & McKenny Co., Seattle, Wash.
Richardson, C. E., Allis-Chalmers Mfg. Co., West Allis, Wis.
Rodgers, W. H., Penn-Ohio Power & Light Co., Sharon, Pa.
Rutherford, J. F., Laurentide Co., Ltd., Grand Mere, Que., Can.
Samoiloff, L., Public Works Engineering Corp., New York, N. Y.
Shamonin, George V., Electric Controller & Mfg. Co., Cleveland, Ohio
Sharp., K. E., Panhandle Power & Light Co., Borger, Texas
Smith, H. B., 1628 Touhy Ave., Rogers Park, Chicago, Ill.
Stoddard, S. W., New England Power Construction, Worcester, Mass.
Tanner, A. E., Cia. A. y de F. E. del Rio Conchos, S. A., C. Camargo, Chihuahua, Mexico
Taylor, A. LeRoy, (Member), University of Utah, Salt Lake City, Utah
Thomas, J. B., (Member), Texas Power & Light Co., Dallas, Texas
Treon, C., Byllesby Engineering & Management Corp., Pittsburgh, Pa.
Wagner, R., Westinghouse Elec. & Mfg. Co., Dallas, Texas
Walker, L. V., Southwestern Bell Telephone Co. Dallas, Texas
Wallace, R. J., Delaware County Electric Co., Morton, Pa.
Wankel, F. A., Brooklyn Union Gas Co., Brooklyn, N. Y.
Ward, R. I., Commonwealth Edison Co., Chicago, Ill.
Whynaught, A. B., John Reardons Sons Co., Cambridge, Mass.
Zedaker, C. E., Jr., Carolina Power & Light Co., Laurinburg, N. C.
Total 62.

Foreign

Cranmer, J. P., British Thomson-Houston Co. Ltd., Willesden, London, N. W. 10, Eng.
Cresswell, W. F., Royal Aircraft Factory, Farnborough, Eng.
Ewart, S. J. M., Hastings Borough Council, Hastings, Hawkes Bay, N. Z.
Gaydon, F. A., Bridge St., Toowoomba, Queensland, Aust.
Gibbs, K. H., Federal Capital Commission, Canberra, Aust.
Komai, K., Hitachi Engineering Works, Sukegawa Ibaraki-ken, Japan
Murthy, P. S., Rajahmundry Electric Supply Corp., Ltd., Rajahmundry, So. India
Nield, H. B., (Member), So Wales Electric Power Co., Upper Boat, Glam, So. Wales, Gt. Britain
Smith, A., Balfour, Beatty & Co., Ltd., London E. C. 4, Eng.
Tangie, A. A., Municipal Council, Sydney, N. S. W., Aust.
Venn, E. F., Yngenio Santa Fe, C. por A., San Pedro de Macoris, Dominican Republic
Total 11.

STUDENTS ENROLLED

Albert, Ralph K., University of Michigan
Alfonso, M. J., University of Detroit
Andrews, Hal J., Missippi A. & M. College
Bairos, Cyril A., Stanford University
Balchan, Stephen J., Stevens Inst. of Technology
Banfi, J. Mario, New York University
Batte, Robert B., Virginia Military Institute
Berglund, Charles W., Jr., Duke University
Betke, A. Fred, University of Southern California
Bevacqua, Frank A., Duke University
Bierwagen, Rudolph W., University of Minnesota
Billingsley, Charles T., Mississippi Agri. & Mech. College
Black, William E., Jr., Virginia Military Institute
Blivin, Morris H., Michigan State College of Agri. & Applied Science
Brown, Gordon H., University of Michigan
Cain, Bernard M., University of Michigan
Cassidy, Robert A., Duke University
Cave, William K., Mass. Institute of Technology
Cliver, Edwin K., Drexel Institute
Coffey, George W., Univ. of Southern California
Colado, Ramon E., University of Cincinnati
Couch, Johnson, O., Virginia Military Institute
Cranford, William E., Duke University
Davison, Edward H., State College of Washington
Dodkin, Donald, Worcester Polytechnic Institute
Downey, Reginald L., Virginia Military Institute
Duckworth, Leonard A., Rhode Island State Col.
Durrett, Ray M., Mass. Institute of Technology
Dutli, Walter F., University of Detroit
Einfalt, Carl R., University of Cincinnati
Faur, Emil T., University of Detroit
Ferguson, John A., Ohio State University
Frankovich, John J., University of Minnesota
Galbraith, John F., University of Wisconsin
Gery, Delma L., Duke University
Goodall, William M., California Inst. of Tech.
Haldeman, William F., University of Detroit
Harness, George T., Jr., California Inst. of Tech.
Higgins, William H. C., Purdue University
Hill, Walter M., Iowa State College
Holley, Richard A., Worcester Polytechnic Inst.
Hopper, Jack H., University of Arizona
Hough, William R., University of Michigan
Hutcheson, Hugh H., University of Washington
Joy, Clarke H., Clarkson College of Technology
Karim, Mahammad A., University of Michigan
Keck, William G., Michigan State College of Agri. & Applied Science
Kennedy, Francis, Worcester Polytechnic Inst.
King, Francis H., Worcester Polytechnic Institute
Klien, Norman E., Oregon State College
Knapp, Kenneth G., Worcester Polytechnic Inst.
Kyle, John S., University of Alberta
Laverty, Clarence A., University of Alberta
Lay, Roy L., Rice Institute
Leary, James H., State College of Washington
Logan, George F., Brooklyn Polytechnic Institute
Marr, John S., University of Detroit
Maston, Andrew F., Worcester Polytechnic Inst.
McCarthy, James H., Worcester Polytechnic Inst.
Menendez, Ramon A., University of Florida
Merrill, Henry M., Univ. of Southern California
Mesina, E. J., University of Detroit
Metcalf, Edgar C., Bucknell University
Miner, Thomas B., Rhode Island State College
Mirgeler, Lester W., Engg. School of Milwaukee
Moore, Harry F., University of Illinois
Moore, John B., University of Wisconsin
Odabashian, Reginald, Worcester Poly. Inst.
Parks, Carlton L., West Virginia University
Perotti, John J., University of Minnesota
Peterson, Ralph M., State College of Washington
Porteous, John W., University of Alberta
Raye, George W., University of Maine
Richards, Arthur R., Michigan State College of Agri. & Applied Science
Rohland, Kurt M., University of Detroit
Sampson, Louis T., University of Illinois
Sandstrom, Frederick G., Worcester Poly. Inst.
Schreiber, Fred J., University of Detroit
Schulte, Edward A., Newark College of Engg.
Scofield, Herbert L., University of Michigan
Scott, Chester F., Rhode Island State College
Simmons, Percy N., University of Illinois
Smith A. Mark, State College of Washington
Smith, Walter E., Ohio State University
Taylor, George A., New York University
Timmons, Ray H., University of Illinois
Torgersen, Harold, New York University
Tsunekawa, Toshio, University of Colorado
Wannamaker, William H., Jr., Duke University
Washington, Silas P., Rhode Island State College
Weathers, Ernest L., Oklahoma A. & M. College
Westrick, M. V., University of Detroit
Whenman, A. Ray, Harvard University
White, Harry P., Virginia Military Institute
Wilson, Pettus K., Jr., University of Florida
Wyer, Richard F., Harvard University
Total 96.

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(A list of the personnel of Institute committees may be found in the June issue of the JOURNAL.)

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ELECTROPHYSICS, V. Karapetoff

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NATIONAL FIRE WASTE COUNCIL

NATIONAL RESEARCH COUNCIL, ENGINEERING DIVISION

NATIONAL SAFETY COUNCIL, ELECTRICAL COMMITTEE OF ENGINEERING SECTION

THE NEWCOMEN SOCIETY

RADIO ADVISORY COMMITTEE, BUREAU OF STANDARDS

SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION, BOARD OF INVESTIGATION AND COORDINATION

U. S. NATIONAL COMMITTEE OF THE INTERNATIONAL ELECTROTECHNICAL COMMISSION

U. S. NATIONAL COMMITTEE OF THE INTERNATIONAL ILLUMINATION COMMISSION

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Louisville	D. C. Jackson, Jr.	N. C. Pearcy, 1631 Deer Lane, Louisville, Ky.
Lynn	W. F. Dawson	V. R. Holmgren, Gen. Elec. Co., Bldg. 64 G, Lynn, Mass.
Madison	J. T. Rood	H. J. Hunt, D. W. Mead and C. V. Seastone, State Journal Bldg., Madison, Wis.
Mexico	B. Nikiforoff	E. D. Luque, Providencia 520, Colinia Del Valle, Mexico, D. F., Mexico
Milwaukee	John D. Ball	Wm. J. Ladwig, Wisconsin Tel. Co., 418 Broadway, Milwaukee, Wis.
Minnesota	J. E. Sumpter	Gilbert Cooley, Rice & Atwater, St. Paul, Minn.
Nebraska	N. W. Kingsley	Roy Hagen, General Electric Co., Omaha, Nebraska
New York	L. W. W. Morrow	J. B. Bassett, General Elec. Co., 120 Broadway, New York, N. Y.
Niagara Frontier	L. E. Imlay	E. P. Harder, 205 Electric Building, Buffalo, N. Y.
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Portland, Ore.	J. E. Yates	L. M. Moyer, General Electric Co., Portland, Ore.
Providence	F. N. Tompkins	F. W. Smith, Blackstone Valley Gas & Electric Co., Pawtucket, R. I.
Rochester	R. D. De Wolf	C. C. Eckhardt, Igrad Condenesr & Mfg. Co., 26 Ave. D, Rochester, N. Y.
St. Louis	C. P. Potter	E. G. McLagan, 2188 Railway Exchange Bldg., St. Louis, Mo.
San Francisco	W. L. Winter	A. G. Jones, 807 Rialto Bldg., San Francisco, Calif.
Saskatchewan	J. D. Peters	W. P. Brattle, Dept. of Telephones, Telephone Bldg., Regina, Sask., Canada
Schenectady	T. A Worcester	R. F. Franklin, Room 301, Bldg. No. 41, General Elec. Co., Schenectady, N. Y
Seattle	C. R. Wallis	Ray Rader, Puget Sound Pr. & Lt. Co., Seattle, Wash.
Sharon	H. B.West	H. B. West, Westinghouse Elec. & Mfg. Co., Sharon, Pa.
Southern Virginia	W. S. Rodman	J. S. Miller, Box 12, University Va.
Spokane	L. R. Gamble	James B. Fisken, Washington Water Power Co., Lincoln & Trent, Spokane, Wash.
Springfield, Mass.	C. A. M. Weber	B. V. K. French, American Bosch Magneto Corp., Springfield, Mass.
Syracuse	C. E. Dorr	F. E. Verdin, 615 City Bank Bldg., Syracuse, N. Y.
Toledo	T. J. Nolan	Max Neuber, 1257 Fernwood Ave., Toledo, Ohio
Toronto	C. E. Sisson	F. F. Ambuhl, Toronto Hydro-Elec. System, 226 Yonge St., Toronto, Ont., Canada
Urbana	J. O. Kraehenbuehl	J. K. Tuthill, 106 Transportation Bldg., University of Illinois, Urbana, Ill.
Utah	Daniel L. Brundige	C. B. Shipp, General Electric Co., Salt Lake City, Utah
Vancouver	A. C. R. Yuill	J. Teasdale, British Columbia Elec. Railway Co., Vancouver, B. C., Canada
Washington, D. C.	M. G. Lloyd	H. E. Bradley, Potomac Elec. Pr. Co., 14th & C Sts., N. W., Washington, D. C.
Worcester	Guy F. Woodward	F. B. Crosby, Morgan Construction Co., 15 Belmont St., Worcester, Mass.
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Case School of Applied Science, Cleveland, Ohio	W. A. Thomas	J. O. Herbster	H. B. Dates
Catholic University of America, Washington, D. C	J. V. O'Connor	R. H. Rose	T. J. MacKavanaugh
Cincinnati, University of, Cincinnati, O	C. E. Young	W. C. Osterbrock	W. C. Osterbrock
Clarkson College of Technology, Potsdam, N. Y	G. L. Rogers	J. S. Loomis	A. R. Powers
Clemson Agricultural College, Clemson College, S. C	A. P. Wylie	W. J. Brogdon	S. R. Rhodes
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Colorado State Agricultural College, Fort Collins, Colo	Harold Groat	Howard Steinmetz	H. G. Jordan
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Spool Insulator Cable Supports.—Bulletin 31-F. Describes a new line of unit type low voltage spool insulator supports developed by the Delta-Star Electric Company, 2400 Block Fulton Street, Chicago, Ill.

Automatic Stations.—Bulletin GEA-90B, 32 pp. Describes the automatic station installations of the General Electric Company up to January 1, 1928. General Electric Company, Schenectady, N. Y.

High Tension Bus Data.—Handbook, 120 pp. Includes tables, formulae and other information describing the design, construction and similar phases of bus work. Burndy Engineering Co., Inc., 10 East 43rd Street, New York.

Floodlighting.—Bulletin GEA-439B, 12 pp., illustrated. A Short Cut to the Solution of Floodlighting Problems. General Electric Company, Schenectady, N. Y.

Arc Welding Equipment.—Bulletin 206, 8 pp. Describes various types of equipment for arc welding, including the variable voltage, single operator type, and the constant potential, multiple operator type. The Lincoln Electric Company, Coit Road and Kirby Ave., Cleveland, Ohio.

Bus Supports.—Bulletin 31-BA. Describes a new line of low voltage bus supports for voltages from 220 to 45000. The fittings are interchangeable with higher voltage supports listed in the Delta-Star bulletin 31-B. Delta-Star Electric Company, 2400 Block Fulton Street, Chicago, Ill.

Maximum Demand Register.—Bulletin 75, 8 pp. Describes Sangamo type HB maximum demand register, which has been greatly simplified in construction and developed to give the longest possible scale reading. It supersedes type HM for both single phase and polyphase meters and is furnished for either type H2 or HC watthour meters. Sangamo Electric Company, Springfield, Ohio.

Lighting Data.—Bulletin LD 144A, 60 pp., "Street Lighting With Mazda Lamps." Includes a bibliography on the subject. Bulletin LD 109C, 32 pp., "Lighting of Schools and Gymnasiums." Both bulletins are well illustrated and conform to the customary high standard of previous publications issued by the Edison Lamp Works of the General Electric Co., Harrison, N. J.

Indoor Cable Terminals.—Bulletin 711, 80 pp. A very comprehensive illustrated brochure describing all Standard cable accessories, principally indoor cable terminals, designed for use in sheltered locations. The bulletin includes cable rating tables and data for the calculation of cable diameters as well as current carrying capacity. Standard Underground Cable Company, 100 Seventeenth Street, Pittsburgh, Pa.

Expansion Anchors.—Bulletin 301, 4 pp. Describes a new "4 in 1" expansion anchor suitable for use in any kind of hard soil, at any angle, and to any depth. These anchors are made of malleable iron, guaranteed against breakage, in four sizes. The particular features incorporated in the anchor are: they may be used as an expanding anchor, as a plate anchor, as a cone anchor and as a slug anchor. James R. Kearney Corporation, 4224 Clayton Avenue, St. Louis, Mo.

NOTES OF THE INDUSTRY

New Cable Grip Company.—The Kellems Products, Inc., 6 Varick Street, New York, has been formed for the purpose of manufacturing and selling the Kellems patented cable grip and a complete line of all old type cable grips.

W. J. Stanton, formerly associated with the Ohio Brass Company, is engaging in a new line of business and is starting a manufacturers' agency located at 120 Broadway, New York. Although during the past few years Mr. Stanton has been located in New York, he previously covered several territories for the Ohio Brass Company.

The Roller-Smith Company, 12 Park Place, New York, announces the following changes in its sales organization: The State of Texas is now being handled by John A. Coleman, 1006 Washington Ave., Houston, Texas. The States of Colorado, Utah, Wyoming and Northern New Mexico are now being handled by H. T. Weeks, U. S. National Bank Bldg., Denver, Colo. Both Mr. Coleman and Mr. Weeks are men of wide experience in the electrical business and with the territories that they are covering. Both will handle the entire line of Roller-Smith products including electrical measuring instruments, relays, and circuit breakers.

The "Hubbard Line Builder" display truck, which was exhibited at the N. E. L. A. convention at Atlantic City, is now on a tour which will include in its itinerary all possible stops where there is likely to be an interest in electric line building materials. The tour will be conducted by Hubbard sales engineers who will have charge of the display truck while it is in their territories. Hubbard pole line hardware and Peirce construction specialties will travel via the "Hubbard Linebuilder" from coast to coast, constantly keeping in close touch with three large Hubbard Plants to receive the latest in Pole Line Construction developments. These three Hubbard and Company factories are located at Pittsburgh, Chicago and Oakland, Calif.

Results of Interconnection of Electric Systems in Great Britain. The British market for electrical apparatus is certain to receive a marked impetus when the super-power system provided for by recent legislation begins to function, according to Assistant Commercial Attache Hugh D. Butler, London, in a trade bulletin just issued by the Commerce Department.

Electrification of Great Britain, it is pointed out, has not developed to the degree one would expect in such a highly industrialized nation. The numerous generating stations which from time to time have sprung up have remained unstandardized and uncontrolled. The new law contemplates the linking of all these stations into one huge electrical system which will provide current to both industry and the home at greatly reduced rates.

Naturally, all manufacturers of electrical apparatus will benefit under the new program. Heavy apparatus, cables, wires, etc. are practically controlled by the British industry; the German and Continental makers sell a variety of supplies and special products on a price basis or because of some special features in design. It is in the expensive high-class type of electrical goods that American manufacturers are prominent and it is in this field that Mr. Butler believes that future expansion of our electrical trade with Great Britain will occur.

The capital invested in the entire electrical industry of Great Britain, including generating station equipment, amounts to approximately $4,000,000,000, of which $375,000,000 represents investments in the manufacture of various electrical products. In 1926 the returns on British investments in electrical supply undertakings averaged 6.21 per cent while in the manufacturing section the return was 7.7 per cent. There has been a steady increase in British electrical companies and undertakings during recent years, the number rising from 1400 in 1913 to nearly 1700 at the beginning of the current year.

Sales of American electrical goods in Great Britain in 1927 were valued at approximately $6,000,000. Included in this figure were household motors valued at $800,000; heating apparatus, $200,000; refrigerators, $412,000; and washing machines, $122,000.